ST. ALBERT'S COLLEGE LIBRARY

CATHOLIC CHURCHMEN IN SCIENCE

Catholic Churchmen in Science

SKETCHES OF THE LIVES OF CATHOLIC ECCLESIASTICS WHO WERE AMONG THE GREAT FOUNDERS IN SCIENCE

BY

JAMES J. WALSH

K.C.St.G., Litt.D., Sc.D., M.D., Ph.D., LL.D.

Director, School of Sociology and Social Service at Fordham University, and Professor of Physiological Psychology, Cathedral College, New York; Fellow of the New York Academy of Medicine; Life Member of the New York Historical Society; Member of the American Anthropological Society; A.M.A.; A.A.A.S.; etc.

Property of
COSA
Please return to
Graduate Theological
Union Library

ST. ALBERT'S COLLEGE LIBRARY

PHILADELPHIA

American Ecclesiastical Review

The Dolphin Press

MCMXVII

261.5
V14
series 3

COPYRIGHT, 1917
American Ecclesiastical Review
The Dolphin Press

To

MY UNCLE

MR. PATRICK GOLDEN

AS A SLIGHT TOKEN OF GRATITUDE
FOR MUCH THAT CAN NEVER
BE REPAID

PREFACE.

THE single rule in the choice of scientist churchmen for this third volume of *Catholic Churchmen in Science* is the same as for the companion volumes—to present sketches of the lives of distinguished scientific workers from various periods of history. The Middle Ages, the Renaissance, the eighteenth and the twentieth century are here represented by men who in the ecclesiastical state and under special religious obligations found the time to do work in science that has made their names immortal in history. In every case their Church affiliations proved a help, not a hindrance, to their scientific work, in spite of the impression to the contrary that is prevalent in many minds in our time.

I have to thank the editor of the *Ave Maria* for permission to reprint the articles on "Laboratories at the Vatican" and "Abbé Spallanzani, a Precursor of Pasteur"; the articles on Abbé Breuil and Father Obermaier have appeared in *The Ecclesiastical Review*, and I am indebted to the editor for permission to use them in book form; that on Cardinal Nicholas of Cusa owes much to the chapter on this distinguished churchman in my *Old Time Makers of Medicine* and to an article on him in the *Archives of Diagnosis.*

There has recently been question of the foundation of an Institute for the Study of the History of Science. Its realization has, alas! been delayed, as have so many other important intellectual developments, by the great war which absorbs nearly all energy and attention. I think that very probably the articles contained in this little volume may serve to emphasize how much such an institution is needed. We have been so intent in the past on the history of war and politics that we have sadly neglected the ordered story of man's great constructive achievements. None of these has been more neglected than the history of science, that is, man's thoughtful efforts to penetrate with the human means at his command the meaning of man's life and the universe in which he lives.

CONTENTS

PAGE

PREFACE vii

I. INTRODUCTION: LABORATORIES AT THE VATICAN AND PAPAL SCIENTISTS 3

II. ROGER BACON 29

III. CARDINAL NICHOLAS OF CUSA 83

IV. ABBÉ SPALLANZANI: A CLERICAL PRECURSOR OF PASTEUR 115

V. ABBÉ BREUIL AND THE CAVE-MEN ARTISTS . . 147

VI. REV. HUGO OBERMAIER: THE TIME AND PLACE OF THE CAVE-MAN IN WORLD HISTORY . . . 183

I.

INTRODUCTION.

IT is hard to find words to express the debt of gratitude which modern civilization owes to the Roman Catholic Church.—JOHN FISKE, *The Beginnings of New England, or The Puritan Theocracy in its Relations to Civil and Religious Liberty.*

ST. ALBERT'S COLLEGE LIBRARY

I.

INTRODUCTION.

LABORATORIES AT THE VATICAN AND PAPAL SCIENTISTS.

PROFESSOR SARTON, a Belgian scholar of distinction, driven from his home country by war conditions there, has been engaged in organizing in this country an institute for the history of science. He was in Washington for some time, in touch with the Smithsonian and other Government scientific institutions; and more recently has been at Harvard. Strange as it may appear, in the midst of all the interest of our day in science there has been comparatively little interest in the history of science until very recent years. The consequence has been a very general misconception of the place of science in the older time. Indeed, except among those who paid particular attention to the history of science, there has been a notion prevalent that there was practically no development of physical science until our time, and that the development of science represented, as it were, a new phase in the evolution of the human mind. Nothing could well be less true than this; for at all times men have been interested in science, and at many times they have made very significant observations and drawn important conclusions from it.

A lack of knowledge of the history of science has made men misunderstand entirely certain phases of the relation of science to education and to religion. There are a great many people who seem to think that, before the last generation or two, the classics had constantly formed the basis of education practically since the old classic days themselves. Very few realize that the classics were introduced under the name of the Humanities, or the New Learning, as the basis of education only in the Renaissance time, and that this phase of education has lasted only some four hundred years. Before that period science was the principal subject of attention at the universities; and indeed practically every topic taken up in university curriculums was studied from the scientific standpoint. This has come to be realized very well by those who understand the significance of what were known as the liberal arts in the older time; for these, in spite of their name, were really seven important phases of education studied as sciences.

On the other hand, the failure to recognize the fact that the medieval universities were all scientific universities has been the fundamental reason for the erroneous assertions with regard to the attitude of the Church toward science. Just as soon as it is understood that the old medieval institutions (founded under papal charters, fostered by churchmen, usually with the chancellor of the cathedral of the university town as the chancellor of the university, with houses of the

various religious Orders connected with the university, and most of the professors ecclesiastics) were quite literally scientific universities, then the idea of any inherent opposition between Church and Science at once vanishes.

Professor Sarton's work deserves, then, thorough encouragement; and an institute for the history of science which would give proper scope for scholarship in this great field would do more than anything else to remove misunderstandings that are almost unpardonable because founded on ignorance. Probably nothing would illustrate better the necessity for an organized knowledge of the history of science for those who are interested in the subject than a passage from Professor Huxley's inaugural address as Lord Rector of the University of Aberdeen, in which he took for his topic " Universities Actual and Ideal." Professor Huxley was usually very careful to look up his authorities and to scrutinize the sources of his information, and seldom made a serious slip; and yet on that occasion he made some declarations which, when investigated in the light of knowledge that has accumulated as regards the history of science in more recent years, prove to be absurdly fallacious. The fallacy of the remark was all the more striking because there are several passages in that inaugural address which I have often quoted, to show that Professor Huxley was quite willing to acknowledge, when he knew it, the good work that was being done by the older universities.

It is said that when Professor Huxley began the preparation of his inaugural address he thought that the best treatment of his subject would be a definite comparison between medieval and modern universities — a comparison which would, of course, prove unfavorable to the older educational organizations, and therefore illustrate clearly and emphasize strongly the necessity for modern modifications in university curriculums which would prove more advantageous for our age. At that time Oxford and Cambridge were still conservatively clinging to the classic curriculum as the essence of education, and presumably were, therefore, still medieval universities in the modern time.

To his great surprise, however, Professor Huxley found that the teaching of the old medieval universities was very different from what he had imagined. He investigated rather carefully the significance of their usual curriculum, recognized that the fundamental principles of it were scientific, and then, after devoting some time to the definite meaning of the trivium and quadrivium, the so-called "seven liberal arts," found that these represented very valuable elements in education. Every one of them was studied from its scientific aspect. Professor Huxley was charmed to find how thoroughly scientific had been the methods of medieval university teachers, so that he did not hesitate to say that the work of these old institutions of learning, "however imperfect and faulty judged

by modern lights it may have been, brought them face to face with all the leading aspects of the many-sided mind of man"; and he added: "I doubt if the curriculum of any modern university shows so clear and generous a comprehension of what is meant by culture as this old trivium and quadrivium does."

There is, however, another passage in the same address that has always interested me even more than this striking expression of praise from so unexpected a source for the medieval universities. Its interest, however, is due to the fact that in it Huxley's customary caution not to make assertions until he had looked up his authorities deserted him. He was caught by the tradition of Church opposition to science, and allowed himself to make declarations that even a little careful study would have shown him to be quite untrue. His address was published in the *Contemporary Review* of the year in which it was delivered, and even so glaring a contradiction of history as is contained in the passage that I shall presently quote, passed unnoticed, and was considered by many, if not practically all, of the readers to represent the actual truth of the matter. It sums up in a few words what was the impression of Huxley's generation, and what has continued to be the impression of a great many people who think they know something about such matters, or indeed often assume that they know all there is to be known about them; and are quite unconscious of the fact that

they are accepting an old-time historical tradition founded on religious prejudice, but absolutely devoid of any foundation in the history of things as they actually happened.

Huxley is talking of the attitude of the Church toward science; that is, of course, toward the physical sciences, and does not hesitate to say with that thoroughgoing completeness of assertion always so characteristic of the man who is dilating on a subject of which he is profoundly ignorant: "Physical science, on the other hand, was an irreconcilable enemy to be excluded at all hazards. The College of Cardinals has not distinguished itself in physics or physiology; and no Pope has as yet set up public laboratories in the Vatican."

I feel sure that most of his hearers at Aberdeen, as well as his readers in the *Contemporary Review,* responded to this sally of Professor Huxley with a good-humored smile over even the bare idea that cardinals should ever have interested themselves in physics or physiology, or that any Pope should ever have set up public laboratories in the Vatican. The very notion was a good joke. I am just as sure that a great many people in our time—indeed, I venture to say most of those who are teaching the physical sciences at the universities—would feel the same way even now. And yet the direct contradictory of both these propositions is quite literally demonstrable of proof; for cardinals and even Popes have distinguished themselves in physics

and physiology, and the Popes during many centuries set up public laboratories in the Vatican. It is not in our time alone that such apparently surprising events have occurred, but it was in the long ago; and there has actually been a definite effort on the part of the Popes not only to keep in touch with physical science, but to foster it, often to endow it liberally, over and over again to honor its great workers, and to encourage their labors in a great many different ways.

To take the second proposition first. The utter absurdity of it in the light of history is susceptible of demonstration without having to appeal to anything more than a modicum of knowledge of history. For there have been Papal astronomers at the Vatican — taking that term, of course, in the generic sense in which Professor Huxley used it of the residence of the Popes—almost continuously for centuries. Pope Leo XIII in his Encyclical *Motu Proprio,* issued some twenty-five years ago, reminded us that "Gregory XIII ordered a tower to be erected in a convenient part of the Vatican gardens, and to be fitted out with the greatest and best instruments of the time. There he held the meetings of the learned men to whom the reform of the calendar had been entrusted. The tower stands to this day, a witness to the munificence of its founder."

Gregory XIII's policy in this matter was pursued faithfully by his successors, though the observatory founded by him fell shortly afterward

into disuse for the purpose originally intended, not at all because of any opposition to science, but because its place was supplied by another Roman institution almost as directly under the patronage of the Popes. This was the Roman College, the great mother school of the Jesuits at Rome.

The Jesuits had a special vow to carry out the wishes of the Popes in all regards. As they were the most important teaching Order of the Church, deeply interested in science as well as in the classics—as indeed under Gregory XIII the scientist in control of the correction of the calendar, holding the charge of the Vatican Observatory, was Father Christopher Clavius, the well-known Jesuit—it is not surprising that succeeding Popes, in order to avoid duplication of work that would be done much more efficiently in a single institution, allowed the Vatican Observatory to lapse, so as to give all their patronage to the Observatory of the Roman College, which really, after all, was in many ways the Papal, or at least the Roman, Observatory. The best proof of this is that the Vatican Observatory has always been restored whenever, as at present, the Jesuits, for any reason, were not allowed to continue their work at the Roman College. There is a Jesuit at the head of it now.

Of course there may be people in our time who do not think of an astronomical observatory as a laboratory, but that is exactly what it is. There are some for whom the word laboratory

means only a chemical laboratory, or at most a chemical and physical laboratory. There is no reason at all, however, for such a distinction, for what is meant by a laboratory is a place where actual scientific observations are recorded and their significance worked out. As the *Century Dictionary* says, a laboratory is "a room, building or workshop especially fitted with suitable apparatus for conducting investigations in any department of a science."

It is interesting, however, to note that this was not the sole form of laboratory that the Popes not only countenanced but patronized, and often endowed. At the older universities the two forms of laboratory work, that is, opportunities for the making of actual observations, were in astronomy and in anatomy. The old medical schools did their laboratory work in the dissecting rooms. It might be thought by many, because of an erroneous tradition in the matter, that surely in this department there would be no likelihood of the Popes having a laboratory; but, then, those who think that the Galileo case demonstrates the utter opposition of the Popes to science would be quite sure that there could have been no astronomical observatory at the Vatican, in spite of the fact that Gregory XIII's observatory just mentioned was established some fifty years before the condemnation of Galileo.

There is a very widespread persuasion that the Popes and the Church were opposed to anatomy; but there is no truth in it. On the

contrary, it is comparatively easy to show, as I have done in my book, *The Popes and Science*, that the Popes encouraged the study of anatomy by dissection, and that the Papal University of Rome at the Sapienza did excellent work in this department, and successive Popes for several centuries invited some of the most distinguished anatomists of their time, who were also, by the way, some of the most distinguished anatomists of all time, to become professors of anatomy at the Papal Medical School. This was not situated at the Vatican of course, literally speaking, but it was so closely in touch in every regard with the Pope that it comes, without any far-fetched construction or undue stretching of significance, to represent a definite contradiction of Huxley's expression with regard to the absence of laboratories under Papal patronage in their capital city.

Among those invited to teach and develop anatomy at the Sapienza were such distinguished anatomists as Columbus, to whom we owe the first description of the circulation; Eustachius, after whom the Eustachian tube is named; Piccolomini, one of the great teachers of anatomy in his time, though his name is attached to no special discovery; Cæsalpinus, one of the most learned men of his day, who had taught botany at Pisa and brought the Botanic Garden there, the first of its kind, into magnificent condition; Varolius, after whom the *Pons Varolii* in the brain is named; Malpighi, who with the highest right of discovery, has his name attached to more

structures in the human body than any other; Lancisi, a great teacher, and a fine original investigator, whose lectures not only attracted students from all over the world, but even brought some of the most distinguished medical men from every country in Europe to listen to them. All this was done at Rome in the Papal Medical School, under the patronage of the Popes, and the important publications issued by these men while teaching at the Papal Medical School were usually dedicated to the Popes.

As to the two forms of laboratory work, then, astronomical and anatomical, that universities took up in the older days, the Popes not only were not in opposition to them, but showed themselves ready to foster and encourage them in every way. There has been no laboratory of chemistry or physics founded at the Vatican, but then circumstances have been different in modern times, and there has been no good reason for the Popes to take such extraordinary steps as such foundations would imply. In the old times their attitude toward science was all-important for its development, and they made their disposition in its regard quite unmistakable by their foundation of laboratories in the two sciences which were studied in this practical way.

When the science of meteorology began to develop, the Popes encouraged that, and did for it very much what they had done for anatomy and astronomy in the older days. During the latter half of the nineteenth century Father Sec-

chi was working at Rome. The Popes took great interest in his work, encouraged his development of astronomical instruments, and also of instruments of various kinds for the automatic observation of the weather, and enabled him to accomplish much in this way.

All over the world Jesuits have been deeply interested in the development of the science of meteorology, and have installed instruments so that there might be larger numbers of observations to collate. The Jesuits in the Philippine Islands reduced these observations to such terms as gave them definite practical results in their ability to foretell storms probably better than others. The sudden severe storms of the Philippine regions had been extremely destructive of life and property, particularly at sea, and the Jesuit developments in meteorology showed that these storms were by no means so sudden as had been thought, but gave due warnings of their coming. Almost needless to say, without the positive encouragement of the Popes such experimentation would not have been allowed to continue in the Order which makes its special vow of obedience to the Pope, and whose general policy is made to conform so strictly to Papal wishes.

As with regard to meteorology, so, too, seismology, the science of the phenomena related to earthquakes and terrestrial tremors of all kinds, has been mainly developed by the Jesuits with the encouragement and even the patronage of the

Popes. Jesuits from distant missionary countries on visits to the Vatican have been asked about their work, stimulated to go on with it; and presents have been made by the Popes themselves as well as by members of the Curia, especially cardinals who wanted to show their interest in this important subject. Huxley's slurring remark, well calculated to raise a laugh, is really an example of ignorance; though, of course, it is rather a question of failure to estimate properly the significance of the factors of the Papal policy expressed in a number of ways. There is an old English maxim, "Laugh and show your ignorance," that is quite literally exemplified in expressions of this kind.

The other expression of Huxley, "The College of Cardinals has not distinguished itself in physics or physiology," might well be thought to be less susceptible of direct contradiction than the relation of the Vatican to laboratories; and yet I may say at once that only a little knowledge of the actual details of the history of science in the older times is needed to show that that, too, is an absurdly ignorant remark. Of course cardinals are ecclesiastics; that is, men devoted to Church work, and therefore it cannot be expected that many of them, whose lives are perforce occupied with interests very widely diverse from physical science, and above all from physics and physiology, should make distinguished contributions to these sciences. And yet it is not difficult to name some cardinals, and at least one

Pope, whose names are associated directly with advances in these sciences. These facts will serve to show clearly that it was not because of any opposition on the part of the Church to physical science that many of its highest dignitaries did not reach distinction in these departments of science, but only because they were occupied with other interests—and even in spite of that preoccupation more than one or two of the cardinals did work that has given them imperishable distinction in the history of science.

Probably the most distinguished contributor to physics and physiology among the cardinals was the great Cardinal Nicholas of Cusa, who was so close to the Popes during the fifteenth century and whose works are full of extremely interesting original observation with regard to subjects related to both physics and physiology. He has a distinct place in the history of medicine; for, as I pointed out in my *Old Time Makers of Medicine,* he was the first to suggest exact methods of diagnosis for medicine. The counting of the pulse rate, and the noting of its relation to the patient's condition, seem very obvious things now; but in his day it was a real scientific innovation. Besides, he taught that specific gravity as a principle for comparative estimation of the fluids of the body might serve to give a scientific basis to diagnosis which it did not possess before. In describing this suggestion of Cardinal Cusa in medical journals I have called it the earliest allusion to accurate methods for

the diagnosis of disease in the history of medicine, which it is. The whole story is very interesting, and the Cardinal's book *De Docta Ignorantia*, that is "On Learned Ignorance," in which he points out how many things there are which people think they know, but which they really do not know at all, represents an accurate scientific point of view usually supposed to be modern.

Any one who wants to realize how very different from the attitude of opposition to science was the position of the Popes and the Church, should read the story of Father Kircher, S.J. It is to be found in the first volume of *Catholic Churchmen in Science*, and makes very clear how generously scientific activities were encouraged in Rome. There is scarcely any mode of physical science that Father Kircher did not pursue with enthusiasm, and his great books are marvels both of printing and illustration and landmarks in the history of science. Brother Potamian, in his catalogue of the Latimer Clark Library of the Institute of American Engineers, calls particular attention to the fact that *electromagnetismos* is the astonishing title which Father Kircher gave to a chapter of his book *Magnes, sive de Arte Magnetica*,—"The Magnet; or, On Magnetic Art," which was published in 1641.

There is scarcely a phase of ordinary physical science on which Kircher did not write a text-book, and these text-books were not little manuals, but huge tomes usually magnificently

illustrated, so that they are now among the bibliographic treasures of the world in the history of science. Besides the book on magnetism already mentioned, three years later there appeared a book on light and shade, *Ars Magna Lucis et Umbrae;* and five years later a book on acoustics, *Musurgia Universalis,* with the subtitle, *Ars Harmoniae et Discordiae,* "The Universal Science of Music and the Art of Harmony and Discord"; and later there was a book on astronomy called *Iter Celeste,* "The Celestial Way"; and then one on geology, metallurgy and mineralogy called *Mundus Subterraneus,* which was often referred to as the author's greatest book, and was translated into a number of modern languages, including English, though in the seventeenth century Englishmen were loath enough to draw their inspiration from Jesuit writers even on such indifferent subjects as science.

Curiously enough, one of his books was called *Physiologia Experimentalis,* which might be translated "Experimental Physiology," though it was really a text-book of experimental physics. It contained all the experimental parts, and especially the demonstrations in chemistry, physics, music, magnetism, and mechanics, as well as acoustics and optics drawn from his larger works on these phases of science. This book of Father Kircher's formed the groundwork of most text-books of science for a full century after his time, and it was freely drawn

upon for matter and illustrations in many countries.

All of these books were published not only without opposition on the part of the Pope, but with the greatest possible encouragement. Father Kircher was making Rome a center of interest for the physical science of the world, and was at the same time the personal friend of many successive Popes, often admitted to private audiences, and asked to explain his most recent discoveries and demonstrate his experiments.

Above all, Father Kircher was active in another field of physical science which I feel sure Professor Huxley would have thoroughly commended had he known it, or rather had he thought of it at the moment when he was making his scoffing observation. Father Kircher is deservedly looked up to as the originator of the modern museum movement. He gathered together a whole host of curios of many kinds in his famous museum, called after him the *Museo Kircheriano,* or more simply *The Kircherianum.* He aroused the lively interest of Jesuit missionaries all over the world, and they sent him curious specimens of many kinds illustrating anthropology, ethnology, zoölogy, folklore, and other phases of natural history and science, usually considered to be much more modern in origin than his time; and he gathered all these together so as to provide material for study. The Popes, when they received curiosities from distant mis-

sionaries, sometimes deposited them with Father Kircher, or willed them to his collection after their death; and this museum is, I think, the pioneer in its line, in the history of the world.

Strange as it may seem to some, there is at least one philosopher-physician among the Popes, though there are of course many more great theologians (and theology is a science), many distinguished philosophers, and many illustrious scholars. The philosopher-physician was John XXI, who had been known before his election as Pope as Peter of Spain and who had been a professor in several universities before he was made a bishop, and eventually raised to the Papal See. Curiously enough, he is the only Pope whom Dante speaks of as in Paradise, placing him beside other such distinguished scholars as Saints Bonaventure, Augustine, Chrysostom, Anselm, along with Abbot Joachim and Hugh of St. Victor. The poet calls Pope John XXI

him of Spain
Who through twelve volumes full of light descants.

The fame of this Pope must have been still fresh in the minds of Dante's generation; for Peter of Spain was born, according to the best ascertainable record, in the second decade of the thirteenth century, living to be past 70 years of age; and as Dante himself was born in 1265, they must have been for a time contemporaries. Peter made his medical and scientific studies at the University of Paris, and in a letter in later

life he confesses that he retains a special affection for Paris, because "within its dwellings he had been brought up from early years and applied himself to various sciences, finding the opportunities provided for education most favorable. After the deep draughts of knowledge there obtained, as far as the God of majesty, the Giver of true wisdom, permitted him to take its opportunities, he does not think that he will be ever able to forget how much he owes to this mother of study."

When he was about thirty-five years of age Peter received an invitation to the chair of physics, as medicine was then called, at the University of Siena. While here he wrote a text-book on eye diseases. Thence he returned to his native country, Portugal, where he became the administrative head of the schools which existed there under the Archbishop of Lisbon. His administrative ability in this position led to his selection, after the death of the incumbent of the See, as Archbishop of Lisbon. A physician archbishop was not such an anomaly then as he would be now, for many ecclesiastics of that time practised both medicine and surgery and became distinguished in this profession.[1]

One of the greatest of the surgeons of the thirteenth century, whose text-book has been preserved for us, was Bishop Theodoric, an Italian. He wrote on the use of anesthetics as

[1] See *Catholic Churchmen in Science*, Series II, for his life.

well as on many modes of operation that are supposed to be quite modern. Monks, and members of religious Orders generally, were forbidden to practise medicine and surgery, and this prohibition is sometimes asserted, but erroneously, to have applied to all clergymen. There is abundant evidence that the secular clergy were quite free, under certain circumstances at least, to continue the practice of both medicine and surgery.

John, the physician, Archbishop of Lisbon, rose subsequently to hold other high positions in the Church, becoming a Cardinal and finally Pope. What is interesting for us here, because of Huxley's contemptuous sneer as to physiology at the Vatican, is that his little book on eye diseases also discusses the anatomy and the physiology of the eye according to the ideas which were prevalent at that time. His work shows that he was familiar with the writings of his age, and it has attracted a good deal of attention from modern ophthalmologists.

Pope John XXI was not the only Pope distinguished in science, for, some two centuries before him, Pope Sylvester II had been the famous physicist and physical scientist of his time. He became well known for his inventions for teaching and demonstration purposes. He lectured on astronomy at Rheims; and in order to make his lectures clearer, he constructed elaborate globes of the terrestrial and celestial spheres, on which the courses of the planets were marked. He ingeniously fitted up an abacus for demonstrations

in arithmetic and geometrical processes; and the development of demonstrations in teaching were evidently his forte. His mathematical apparatus is said to have had twenty-seven divisions and a thousand counters of horn. There are some speculations on light from him, and he was very much interested not only in music but the scientific aspects of sound. William of Malmesbury has incorporated into his chronicle a description of a great complex musical instrument, which was still to be seen at Rheims in his day and which was attributed to Gerbert's inventive and mechanical ability. A contemporary declares that Gerbert made a clock, or sundial, at Magdeburg which measured the hours exactly, and that it was soon imitated throughout Europe.

What particularly takes the point out of Professor Huxley's passing jest on the supposed utter impossibility of the Popes having ever had laboratories at the Vatican, or the cardinals doing anything for physiology, is the fact that one of the most noteworthy features in the lives of not a few but very many Popes is their friendship for distinguished scientific workers of their generations. I have already mentioned Cardinal Nicholas of Cusa, probably the greatest scientific genius of his day, and his intimate relations not alone to one but to three or four Popes of his time. In the thirteenth century the men most highly honored at Rome were Albertus Magnus, Thomas Aquinas, and others whose works contained many significant references to physical

science, who discussed seriously the philosophic problems that underlie scientific principles, and who gathered together all the information that could be secured. In this regard it must not be forgotten that we owe to Roger Bacon great books, the contents of which would have seemed utterly beyond comprehension or imagination as having been compiled in his time, did we not actually possess them. That possession is due to the friendship of Cardinal Foulques, who was afterward Pope Clement, for Roger Bacon. In similar fashion we probably owe most of the precious writing of Constantine Africanus to the persuasion of Abbot Desiderius, who was afterward Pope Victor III, and who continued while Pope to encourage Constantine in his writing.

In the latest edition of my volume on *The Popes and Science* I have devoted a special Appendix of nearly fifty pages of rather small type to the story of the Papal physicians. There is no set of men whose names are connected together by any bond in the history of medicine who are as distinguished as these Papal physicians. Many of them are famous for distinguished original work. All of them had done some at least of the work to which they owe their fame before being invited to Rome to continue it there. It was because of their reputation as great original scientists that they were invited to Rome to become the Papal physicians. I know nothing in the whole history of science which makes it so clear that, far from opposing science

in any way, the Popes wanted to encourage and patronize it to the best of their ability, as the fact that when they wished to appoint a Papal physician they chose one who was famous in the scientific world, and gave him the prestige of this position, which assured him a place in the Christian world higher than any that could be secured in any other way.

It is easy to remember what confidential relations existed between the Popes and their physicians. We can judge of them very well from the relations between educated men and their physicians at the present day. In the older time physicians were even less likely to be narrow in their interest in science than they are at present; and, as a matter of fact, many of the Papal physicians made important contributions to the sciences related to medicine, and not a few of them were distinguished pioneers in the biological sciences. Nothing could have been better calculated to maintain a favorable attitude toward science and its advances on the part of the Popes than the presence in so influential a position close to them, of representative physicians who had been honored by their fellows in many ways and had done distinctly original scientific work.

Between the appointment of Papal physicians and the maintenance of Papal astronomers, the Popes certainly did all they could to keep properly in touch with physical science and even to maintain laboratories at least in anatomy and

astronomy, and to encourage in every way the development of these two important sciences Under these sciences in the older days were included, on the one hand, not a little of physics and mathematics, and on the other a great deal of physiology, and by its medical relations much of chemistry and the related sciences. Only profound ignorance of this could possibly have permitted Mr. Huxley to indulge his humor, at the expense of the Popes as he thought, though it was really at his own expense; for his expressions make it very clear that this phase of knowledge had never come to him, and that he too, like so many others, was being led astray by the Protestant prejudice with regard to the attitude of the Popes toward science. It was Huxley himself who wrote home from Rome to St George Mivart, the English biologist, that he had been looking into the Galileo case and found "that the Pope and the cardinals had rather the best of it." What he meant was that the ordinary impression with regard to the Galileo case was founded on a misconception of the real nature of that celebrated case.

In spite of this recognition of the rôle that prejudgment plays in such cases, Huxley, as we have seen, allowed himself to be led astray by a similar misunderstanding with regard to the general policy of the Church toward science. The Galileo case, even if it were what many people imagine it to have been, an attempt to throttle science — which of course it was not — is the

single example of that kind of activity that most people know anything about; and, as Cardinal Newman remarked, if this is the single exception in a policy of 600 years, then it is surely the exception which proves that the very opposite was the rule.

Even Huxley, however, in spite of his rather careful investigation of such disputed points in general, did not have available sufficient details of the knowledge of the history of science to appreciate the real place of the Popes with regard to it. They were literally patrons of science, just as much as they were of art and education and literature, even to the extent of making foundations for astronomical observatories and anatomical laboratories in their capital city when there was ever so much more need for patronage than there is at the present time. When these were the only two kinds of laboratories organized in science, both of them were to be found at Rome under Papal patronage, and in both some of the best work of the world was being done.

Manifestly, then, there is a place for an institute of the history of science, and its collections and the investigations that it will initiate and encourage cannot fail to do a great deal to remove erroneous impressions, above all with regard to the relations of science to education and religion. What we need is more knowledge, and then prejudice will disappear. Modern scientific history, by replacing vague impressions with exact documentary details and altering undocu-

mented convictions into reasonable open-mindedness, has done an immense amount already to clear up historical fallacies with regard to the Church. The history of science carefully written would be of enormous weight in removing all sorts of prejudices which have accumulated since the Reformation; for the one idea of the Reformers and their successors has been to make people believe that until the sixteenth century there was nothing at all worth while being done in the intellectual order, and that, above all, men were not free to think for themselves.

II.

ROGER BACON.

THE Encyclopedia and Novum Organon of the thirteenth century, a work equally wonderful with regard to its general scheme and to the special treatises with which the outlines of the plans are filled up.—WHEWELL, on Roger Bacon's *Opus Majus*.

THEN Aquinas summed up in his profound speculations the substance of Catholic Theology, and while the morning twilight of modern science might be discerned in the treatises of Roger Bacon, while wandering minstrelsy revealed the treasures of modern speech, soon to be wrought under the hands of Dante and Chaucer into forms of exquisite beauty, the sacred fervor of the apostolic ages found itself renewed in the tender and mystic piety of St. Francis of Assisi. It was a wonderful time, but after all less memorable as the culmination of medieval Empire and medieval Church than as the dawning of the new era in which we live to-day.—JOHN FISKE, *The Beginnings of New England, or The Puritan Theocracy in its Relations to Civil and Religious Liberty.*

II.

ROGER BACON.

THE last international function in the academic world to attract the attention of the civilized countries before the great war of 1914 separated civilization into elements so bitterly discordant as to make even the thought of a reunion of university men of the different countries of Europe quite out of the question for years perhaps, was the celebration at Oxford University in England in June, 1914, of the seven hundredth anniversary of the birth of Roger Bacon. According to a reasonably well-founded tradition the *Doctor Mirabilis*, as he has been called, "the wonderful teacher" (for doctor had not lost its pristine significance), was born in June, 1214. Seven hundred years is a long time for a man to be so remembered that his birthday is celebrated even by his fellow-countrymen, but such a celebration has even greater significance when it attracts international attention. Usually the men whose memory is thus recalled centuries after their death, have made significant achievements in war or politics, achievements that permanently affect the status of a nation and so readily suggest anniversary celebrations.

Very seldom indeed is it that intellectual accomplishments are deemed worthy of recognition of this kind hundreds of years afterward.

It is all the more striking, then, that the name and fame of a medieval scholar should have been thus gloriously honored by the university authorities of the world seven centuries after his time and that his work should be so emphatically recalled to public attention. It is, above all, an index of that newer, truer knowledge of the medieval period which has been coming to us for the past two or three generations and which has culminated now in the very general recognition, that the later centuries of what used to be called the benighted Middle Ages, or even the Dark Ages, were among the most wonderful in the history of the race and that particularly the thirteenth century, which Roger Bacon's life so largely represents for us (for he was born in the first part of its second decade and lived into its last), is one of the supreme periods in the history of humanity.

Lest it should seem a subject for special surprise that a medieval scholar, a university man of that thirteenth century, should have been the subject of such a celebration in our time, it probably deserves to be recalled here that the only scholar in all history with whose name the adjective "great" has come to be so associated now that it is the ordinary impression that it is a part of his name, was a contemporary of Roger Bacon's. This was, of course, Albertus Magnus, whose family name, Albert of Bollstadt, has been lost sight of entirely in the appellation *magnus* conferred on him by the generation that imme-

ST. ALBERT'S COLLEGE LIBRARY

diately followed him. Albert and Roger Bacon met on more than one occasion and knew each other's works very well, though mainly to disagree on many important questions. They were quite as much opposed in habit of mind and philosophic viewpoint as any two schools of rival thought in our time. In spite of this difference of opinion, both of them are deservedly in honor, for both had certain ways of looking at things that will ever attract human attention.

Probably the greatest surprise with regard to the recent celebration of the anniversary of the birth of Roger Bacon is that it was arranged by the Royal Society of England, an organization strictly scientific in its aims, and that it attracted the particular attention almost entirely of the scientists of the world. It is because Roger Bacon anticipated many things in what we are pleased to call modern physical science that his septicentenary was enthusiastically celebrated. We have become very much interested in science during the past three generations, but until quite recently in our own generation there was a very prevalent impression that no development of science worth while talking about had taken place before the last century or two, and above all that no scientific thinkers or workers worth while recalling had lived until almost our own time. At last, however, we are waking up to the realities of the history of science and have come to recognize the fact that a great many of the underlying fundamental and most significant

ideas in it were in the minds of men generations before our time. This was indeed the real meaning of the international celebration of the seven hundredth anniversary of the birth of Roger Bacon.

The same ignoring of other modes of achievement in mankind before our time has been very common in the last few generations, and it is as a ground for hope that there may be further awakening to our ignorance of many wonderful things in the past, that the celebration of the Bacon centenary has its most promising interest. The fact of the matter is that it is only as our own interests develop that we come to recognize the significance of interest in the older time. When we had no architecture, no arts, no crafts to speak of, and when our books were cheap and vile (*vile* in Latin means for sale), we could not appreciate many of their interests in the Middle Ages, when they were devoting themselves to the making of beautiful buildings, charming arts and crafts work and handsome books. When we had no agricultural schools, we could not appreciate that the monasteries were agricultural schools and were doing fine work for drainage, irrigation, and the improvement of agriculture in every way. Our knowledge of the Middle Ages is growing, but above all our own development in other ways is gradually coming back to the level of the medieval period, and so we are coming to appreciate better the work of its scholars.

So it is with these medieval scholars like Roger Bacon. The last three or four generations of mankind have wakened up to the scientific ideas that occupied the generation to which Roger Bacon, Albertus Magnus, and Thomas Aquinas belonged, after a long period during which there was a stagnation of scientific ideas. A great many people seem inclined to think that all higher education before our time was founded on the classics. But they forget that the classics as the basis of education came in only with the New Learning in the Renaissance time, and that the old medieval universities were really scientific universities. It was no less a protagonist of modern science than Thomas Huxley who in his address as the Rector of Aberdeen University some thirty years ago, reviewing early days of university teaching at Aberdeen, did not hesitate to declare that the so-called seven liberal arts as taught in the old universities were viewed really from a scientific standpoint and that they provided "a better instrument for the development of the many-sided mind of man than the curriculum of any modern university." [1]

Bacon's Eclipse.

Perhaps the most interesting feature with regard to the present-day reawakening of high estimation for Roger Bacon is to be found in the

[1] See Chapter on Laboratories at the Vatican, for quotation.

fact that while there are many references to Bacon in our English literature, practically all of them after the end of the Middle Ages are in a spirit of supreme depreciation. Oxford, which now turns to honor her son, was the leader in these. Bacon's name became a byword. The brazen nose of Brasenose College was said to be Bacon's head. Many the joke there was about it. It was much worse than what we could call a "bone head"; it was a head of bronze into which no idea could be made to penetrate. Even as late as 1818 Lord Byron has some contemptuous references to Friar Bacon's brazen head, though these were probably only a reëcho of the literary traditions of the Elizabethan time when Bacon was looked upon as a conceited ass or else an impudent imposter.

All this only proves now to have been just a question of a genius misunderstood. It is a dangerous thing for a man to be ahead of his time, though what is usually forgotten is that it is just as dangerous for a man to be behind his time. The truth of the matter is that at moments when ideas are taken seriously and mankind is in the midst of a critical period, it is dangerous to disagree with one's fellows. We thought that men had outlived this, or had been educated beyond it, until this war showed us that men reason no more now than at any other time. They adopt certain views and then are prone to assume that anyone who disagrees with them cannot be quite sincere. Roger Bacon was a genius and thought

for himself, and disagreed with a great many in his own generation, so that it was no wonder that he proved an excellent exemplification of one of Dean Swift's famous expressions. The satiric Dean of St. Patrick's said, " When a true genius appears in the world, you may know him by this sign—that all the asses are in confederacy against him." The confederacy against Bacon was not so much noted in his own time as in the centuries after the Middle Ages, and it continued until the world caught up with the ideas which the medieval friar had advanced and by which he had anticipated modern thought.

It is not really a source of surprise then, or should not be, that the modern scientific world should go back seven hundred years to celebrate the birthday of a great man of the medieval period, but what is surprising is that it should have taken so long for the modern world to wake up to the fact that these old-time scholars were working at the same problems as the most modern of scientists, and were occupied even with the practical application of scientific principles to human utilities quite as we are. Bacon, for instance, discussing gunpowder and explosives generally, very calmly suggested that a time would come when carriages would run over the land without horses or men pulling them, and boats over the sea without oars or sails. His idea was that sometime man would harness explosives; and when it is recalled that the two great sources of energy for locomotion on land

and sea, steam and gasoline, are both of explosive nature, it would be easy to understand how acute was Bacon's provision. He also suggested that men might make flying machines, and was quite sure that the problem of aviation would some time be solved and would not prove very difficult. As a matter of fact, as he so clearly anticipated, just as soon as we had harnessed explosives, locomotion on sea and land and in the air became an easy problem.

For us here in America the story of Roger Bacon must ever be of special interest because of the fact that it was a passage from one of Bacon's works, the *Opus Majus*, which above all influenced Columbus to come to the conclusion that land could be reached by sailing westward. Cardinal Pierre d'Ailly made a quotation from Bacon's chapter on Geography in the *Opus Majus* in his work, the *Imago Mundi*. Columbus was so impressed by these expressions from Bacon that, after making a commentary on them, he quoted them in a letter that he wrote to Ferdinand and Isabella, making clear to them the fact that his notion of sailing westward was not a novel chimeric scheme, but that some at least of the best scientific thought of the world for two or three centuries had been converging on this westward exploration; and he urged this as an additional motive for them to patronize it. Bacon's *Opus Majus*, therefore, as the source of inspiration for Columbus was an important factor for the discovery of America, and if Columbus is to

be considered, as of course he ought to be, as the father of the great idea that led to the discovery of America, then Roger Bacon must be looked up to as a direct progenitor of that same genial idea.

A good many historians of education have been very much inclined to laugh at the high-sounding titles, given in almost absurd flattery it would seem, which the medieval scholars conferred on their masters. *Doctor angelicus, mirificus, subtilis, accuratissimus*, and so on, represent for them only refined flattery and lofty compliment, doing much more credit to the heart of the students of the Middle Ages than to their minds. Not a few presumably well-informed people might be of the opinion that the ignorance of the students was so profound that anything more than ordinary knowledge on the part of their masters must have seemed wonderful to them. After recalling even a little of the influence that Bacon had on the greatest minds of the subsequent centuries, and then the highly complimentary renewal of interest in him which has taken place in our own time, one comes to appreciate more and more how eminently suitable for him was the name *Doctor Mirabilis*, under which he was known and which he surely merited highly, if any teacher ever did. If his case is to be taken as evidence for others, then these titles of the Middle Ages so far from being idle flattery given to favorite professors must have been amply deserved.

The story of the man of this prophetic vision, who on strictly intellectual grounds foresaw long subsequent scientific interests, and his career as a scholar of the most varied liberal interests, are among the very precious chapters in the history of the human intellect. It is quite impossible to tell it all in the limitations of our space, but at least some of the most important headings may be discussed briefly, especially in their relation to present-day life and thought.

An Old-Time Academic Career.

Roger Bacon was probably born near Ilchester, though not in Somersetshire, in which Ilchester is located, but across the line in neighboring Dorsetshire. He was a younger son of a noble family of which there was a number of branches in England and Normandy. His elder brother, whom he describes as "my rich brother," succeeded to the estates. There was another brother whom Bacon describes as "a scholar." There was a famous Robert Bacon, a well-known teacher among the Dominicans, who died in 1245 and who is said to have been Bacon's uncle. Bacon went to Oxford about 1226, when he was twelve years of age, and continued to live either at Oxford or at Paris for the next forty years. In 1267 Bacon declared, "I have always been studious, and except for two of those (past) forty years I have always been *in studio*." This last phrase probably does not mean merely engaged at study but "at a university," for the

usual title in the thirteenth century for what we call a university was *studium generale*.

His university life for these forty years was passed between study and lecturing. He lectured both at Oxford and at Paris, and attracted great attention and made many favorite pupils. He wrote a number of elementary treatises for students, so that, as he says himself, "men used to wonder before I became a friar that I lived, owing to my excessive labors." They could not understand where he got the time, but above all they were sure that he would break down his health by his constant application. In the light of this it is rather interesting to realize that in spite of a life of the most strenuous intellectual activity he probably lived to be over eighty years of age, intellectually capable and active until the very end.

Undoubtedly he owed the maintenance of his intellectual vigor to the breadth and variety of his mental interests. Probably no one in his time in the west of Europe knew so many languages and knew them so well; he was the greatest mathematical thinker of his time; he was a tireless experimenter in what we call physics and chemistry; he was a writer on many subjects, including philosophy and theology, as well as Hebrew and Greek grammar; and with all, he was a professor whose students valued him highly. All this intense occupation of mind, far from shortening his life, left him vigorous mentally and physically until the very end. We have

had many similar examples in recent years of men of extremely varied intellectual interests so intensely busied that all their friends were sure that they would shorten their lives, yet living on to four-score years or more of the most precious activity.

This academic career of Bacon's for forty years gives a better idea of medieval university life than many a volume of the history of education can furnish. There are many reasonably well-informed people who seem to think that the development of graduate or so-called post-graduate work at our universities in the modern time represents a new phase of evolution in education. As a matter of fact, as was emphatically pointed out by Mark Pattison, when as the rector of Lincoln College he made his "Suggestions for Academical Organization with Especial Reference to Oxford," the colleges of the medieval universities were "in their origin, endowments, not for the elements of a general liberal education, but for the prolonged study of special and professional faculties by men of riper age. The universities as a whole embraced both these objects. The colleges, while they incidentally aided in elementary education, were specially devoted to the highest learning." He says further: "Unfortunately the colleges no longer promote the researches of science or direct professional study. Elementary teaching of youth under twenty is now the only function performed by

the university and almost the only object of college endowments."

It is easy to understand from Bacon's career how true it is that, as Mr. Pattison said, the colleges of the Middle Ages "were homes for the life study of the highest and most abstruse parts of knowledge. They have become boarding schools in which the elements of the learned languages are taught to youths." No wonder that the commissioners who reported on the University of Oxford in 1850 wrote: "It is generally acknowledged that both Oxford and the country at large suffer greatly from the absence of a body of learned men, devoting their lives to the cultivation of science and to the direction of academical education. "The fact that so few books of profound research emanate from the University of Oxford materially impairs its character as a seat of learning and consequently its hold on the respect of the nation."

Things were very different in the Oxford of the middle of the thirteenth century from this mid-nineteenth century condition; and it is a curious reflection on modern progress in education that just in proportion as Oxford and our modern universities generally have improved, they have approached more nearly to the ideals and methods of the medieval century.

At Oxford in his younger years Bacon was very deeply influenced by his masters there, and it is not surprising that this was so as soon as we know the name of the masters. Among them

were such men as Edmund Rich, subsequently Archbishop of Canterbury, and Robert Grosseteste, afterward the Bishop of Lincoln. Robert, whose other name, as we know him, was only a nickname "great head" because of the size of his head, with an innuendo as to how much it contained, was the Chancellor of Oxford and the first Rector of the Franciscan College there in Bacon's student days. Though born of poor parents and without any advantages of birth or person, Robert became unquestionably "the first English scholar of the age". Two other distinguished members of the faculty at Oxford of this time, also teachers of Bacon, were only less well known, Richard Fitzacre and Adam Marsh. The latter, known also as Adam de Marisco, bore the title, "the illustrious doctor". Bacon, by no means prone to overpraise, and certainly never guilty of flattering the members of his own Order, to which Adam belonged, declared him "a man perfect in knowledge, divine and human".

The Franciscan Friar.

After great success as a teacher, Bacon at the rather mature age of thirty-five, or perhaps even older, joined the Franciscans. Modern writers have expressed surprise that Bacon should thus bury himself in a religious order; but surely, if anyone knew what he was doing, it was this university man who for twenty years had been in contact with all the great scholars of the time.

The more one knows of the intellectual life of the period the easier it is to understand how men deeply interested in the life of the spirit, whether purely mental or strictly spiritual, turned very naturally to the religious orders. Here was peace and freedom from the strenuous life of the time — just as strenuous and busy as the world has been at any time; and above all, here was the opportunity for association with distinguished scholars who as teachers and students brought emulation and inspiration and stimulation into life. The distinguished Franciscans among his teachers serve to make it quite clear why Bacon should have joined that order at the height of his reputation as a university lecturer.

His entrance into the Franciscan friary seems not to have interfered with Bacon's university life, and apparently he was afforded abundant opportunities for the pursuit of knowledge. In the *Opus Tertium* in 1267 he said: "During the twenty years in which I have labored, specially in the study of wisdom, after abandoning the usual methods, I have spent more than 2000 librae on books not easily to be secured and various experiments and languages and instruments and mathematical tables." A *libra parisiensium* was, according to Bacon himself, only equivalent to a third of a pound sterling. This would amount to some $3,500 in our money; but according to the value of money at that time would probably be ten times that amount. This is a very large sum of money to spend on

investigation and research, and it probably includes Bacon's private means before he became a Franciscan and then various sums given to him afterward by enthusiastic students and their relatives which he was allowed to expend for academic purposes. Probably nothing shows better the deep interest of the time in scholarship and intellectual development than this liberal expenditure for it.

The prophecies of his friends that he would break down under the strain of the immense amount of labor he was undertaking were fulfilled, though the breakdown is sometimes said to have been due as much to the privations and mortifications of his religious life as to his devotion to intellectual labor. For some ten years, from about 1256 to 1266, he had, "owing to many infirmities", to withdraw from taking any public part in university affairs. Biographers, anxious to find evidence for the intolerance of the Church authorities at this time, have declared that Bacon was imprisoned during this period, or that he was forbidden to teach at the universities. There is not the slightest foundation for any such declaration.

So far from being out of touch with the intellectual life of the time during his illness, he seems to have had, if possible, even a wider interest than before. Professor Little, Lecturer on Palaeography in the University of Manchester, England, who wrote the Introduction to the Commemoration Essays for the celebration of

the seventh centenary of Bacon's birth,[2] has a paragraph with regard to Bacon's activities during this period of withdrawal from university duties because of his health, which shows better than anything else how busy a man Bacon could be.

We have a glimpse of him in Paris during this period listening to a tale of magic. He seems to have been in the habit of supplying new masters of arts at their inception or inaugural disputation with problems in geometry which none of their hearers could solve. He was mainly occupied in investigations and experiments in physics, especially optics, in making lenses, in constructing astronomical tables, and elaborating his theory of the propagation of force. He devoted his leisure to instructing boys in mathematics, sciences, and languages: one of them, John, who came to him poor and eager to learn, about 1260, at the age of fifteen, he supported through alms begged from friends and instructed gratis for the love of God and afterward employed as his messenger to the pope. He kept himself thoroughly informed on what was going on in the world, and uses contemporary political and social events to illustrate his points. The Children's Crusade and the Revolt of the Pastoureaux afford him instances of "fascination". The quarrels between Henry III and the barons in England, the relations of the English and French kings, the struggle between Empire and Papacy and final overthrow of the Hohenstaufen by Charles of Anjou, the Crusades of St. Louis, the agitation of William of St. Amour in the University of Paris, are

[2] *Roger Bacon,* Essays Contributed by Various Writers on the occasion of the Commemoration of the Seventh Centenary of his Birth; collected and edited by A. G. Little, Oxford, at the Clarendon Press, 1914.

among the subjects he alludes to. He draws attention to the cruelties of the Teutonic knights and points out how fatal these were to the efforts of the friars to convert the heathen Slavs to Christianity. He knew of the great German Friar Berthold of Regensburg. The magnificent work he is doing in preaching is of more value than that of almost all the other friars together. He was profoundly interested in the discoveries of the great travelers of the time, especially William de Rubruk. "I have perused his book diligently and conferred with the author, and with many others who have investigated the geography of the East and South." In speaking of mechanical discoveries: "I have not seen a flying machine," he says in one place, "and I do not know anyone who has seen one: but I know a wise man who has thought out the principle of the thing."

Bacon the Writer.

It was just at the end of this period of retirement that, fortunately for posterity, Bacon's great opportunity to write his books came. In 1265 Guy de Foulques, Archbishop of Narbonne, was elected Pope and took the title of Clement IV. He probably had met Bacon in Paris. There is some question whether they had not also met in England. In March, 1266, the Pope heard from Sir William Boncquor, a special envoy sent by Henry III, of some of the wonderful work that Bacon was engaged at. In June of that year the Pope wrote to Bacon bidding him send a fair copy of the works of which he had heard, for Papal perusal. Apparently his Holiness was not quite sure whether he would be able to approve everything in them, and so he advised their being sent "secretly but without

delay", and added that they were to be sent "notwithstanding any constitution of the Franciscan Order to the contrary".

Apparently the Pope thought the works were already written. Bacon thought this was an opportunity to set forth his ideas as to the whole realm of knowledge; but, finding his first project too elaborate, he settled down to write the *Opus Majus*, which was later supplemented by the *Opus Minus* and the *Opus Tertium*.

In the meantime he explained to the Pope the reasons for the delay. Besides his poor health, there was the want of money, for parchment was not cheap, and his vow of poverty was in the way; also there was lack of assistance, and it was very difficult to find competent and trustworthy copyists. A matter a little difficult to understand was that his superiors were putting obstacles in the way, though of course the Pope had asked that the work be done secretly, doubtless so as to avoid the appearance of approbation for everything that was written before it had actually been read by the authorities. One reason for the delay is extremely interesting, because it tells us of Bacon's habits of composition. He said, "Anything difficult I have to write four or five times before I get what I want". We hear much of uncritical ways in the medieval period, but manifestly Bacon might be compared to our own Cardinal Newman in his striving after the exact word and the supreme mode of expressing his ideas. Eventually the books were finished

and dispatched to the Pope. That is how we come to have any authentic account of a great deal of Bacon's thinking.

Physical Science.

Bacon's most important contribution to science in his time was undoubtedly his cultivation of the science of optics. The fifth part of the *Opus Majus* is entirely devoted to this subject. As Little says in the Introduction to the *Bacon Essays*, "One can readily understand how this should be for Bacon the very type of physical science. It is exactly conformed to mathematical law. In fact, one may say that his grand idea of all physical science as mathematical in nature was simply an inference from what was so palpable in optics." This contains a discussion not only of the theory of lenses, to which is added a treatise on burning glasses and of the construction and properties of mirrors, but also an attempt to explain the psychology of perception and something of the anatomy and physiology of the eye. Bacon was never less than complete in his outlook upon the subject, though there might be imperfections in his knowledge of details. What interested him particularly were the laws of reflection and refraction. When laws could be deduced, then the great scientific mind of Bacon was satisfied.

Undoubtedly Bacon's greatest scientific discovery is his declaration that light travels with an appreciable velocity. In his *Opus Majus* he

declared that all the authors, including Aristotle, hold that the propagation of light is instantaneous. This is not a surprising opinion, seeing that light travels at the rate of 185,000 miles a second, and that therefore with our human limitations of vision this is practically instantaneous. It was not until Römer pointed out that the sun's light, after an eclipse, takes an appreciable time to reach us, that we had the demonstration that light travels with a definite velocity. In spite of the difficulty of the determination, which amounted almost to an impossibility in his time, Roger Bacon set it down very definitely that light propagation takes a short but measurable interval of time. Humboldt in his *Cosmos* has attributed to Francis Bacon this discovery, but the English Chancellor in this, as in many other ideas, was long anticipated by his namesake of the thirteenth century.

Usually it is thought that, while some of the principles of physics were anticipated in the later Middle Ages, chemistry was as yet lost in the mists of alchemy. Mr. Patterson Muir, in his essay "Roger Bacon: His Relations to Alchemy and Chemistry", published in the volume of Commemoration Essays, does not hesitate to say that it is only just to class Roger Bacon as a chemist rather than as an alchemist. The reason for this is that Bacon insisted on the knowledge that could be secured of the substances all round us by direct experimental methods and analytical observations. He dwells on the necessity to the

alchemist of a practical acquaintance with the methods of distilling, calcining, separating, and the like. He unhesitatingly recommended the employment of these methods as the only way to accurate and fruitful knowledge of the changes of material things. Instead of discussing theoretically matter and form, he thought that the way to know something about matter was to analyze it as far as possible and note the changes that took place in it.

While much of what Bacon has to say with regard to what we now know as chemistry in his *De arte chymiae* cannot but seem quite absurd to the reader of our time familiar with modern chemistry, one very curious fact deserves to be noted. Many of his ideas would have seemed ever so much more absurd a generation ago than they do at the present time. Bacon regarded silver, for instance, as a kind of lead burdened by imperfections. He thought that it would be quite possible to obtain gold from other metals by removing the infirmities, that is, curing the sicknesses of certain other metals. Some of our physical chemists have come to think it very possible that silver may be only a development of lead in some as yet not comprehended radiant energy process and that gold may bear the same relation to copper. An American chemist said not long since that he would like very much to have the opportunity, after having removed all the silver from a quantity of lead ore, to come back years afterward in order to determine

whether in the meantime some further silver had not developed in what had been argentiferous material. With that idea Bacon would have been entirely in sympathy.

The Invention of Gunpowder.

The question as to whether Bacon was the discoverer of gunpowder or not, about which there has been so much dispute, was discussed in the volume of Commemoration Essays by Lieutenant Colonel H. W. L. Hime, an English authority on the history of military affairs. He is quite sure that gunpowder was a discovery of Bacon's. He would prefer not to call it an invention, for he thinks that it was "discovered accidentally by Bacon; just as the structure of crystals was discovered accidentally by Haüy, the polarization of light by Malus, galvanism by Galvani, and the decomposition of water by Nicholson". He dismisses supposed anticipations of this discovery of Bacon's as follows:

> The famous Greek fire was not an explosive, but an incendiary mixture. The claims to the invention of gunpowder which have been made for the Arabs and Hindus collapse when critically examined. The invention has always been disavowed on the part of their countrymen by sober Chinese historians, though in despite of them a claim was raised in the eighteenth century by some Jesuit missionaries who unwittingly confounded explosives and incendiary mixtures.

One of the most important ingredients of gunpowder, saltpeter, was unknown until shortly be-

fore the middle of the thirteenth century; but many of its explosive qualities attracted attention about that time. While Bacon was experimenting with some incendiary composition containing saltpeter, charcoal, and sulphur, the mixture suddenly exploded, shattering the glass and scattering the brazen apparatus that lay near. Bacon's description of the material of his compound is very cryptic. There seems to be no doubt that he used a cipher in giving in his writings the details of it. Colonel Hime thinks that he did this because he was afraid that, if it became known, he would be accused of magic, and has much to say about the Inquisition. The dear Colonel evidently has a bugaboo about the Inquisition, though there is no reason at all for thinking that that ecclesiastical institution interfered in such matters. What is much more in accordance with Bacon's well-known reticence is that, having become accidentally possessed of a dangerous secret and wanting to record it, he did so in a manner that would prevent those who might use such a secret for wrong purposes from taking advantage of it, yet in such a way as to make a permanent record of his own experiences.

Experimental Science.

Bacon has many expressions which indicate that in science authority can mean very little and experiment must be the source of knowledge. In the chapter of the *Opus Majus* entitled "Scientia Experimentalis", Bacon insists that,

" without experiment nothing can be adequately known. An argument proves theoretically but it does not give the certitude necessary to remove all doubt; nor will the mind repose in the clear view of truth unless it finds it by way of experiment." In his *Opus Tertium* he went even farther and suggested emphatically that "the strongest arguments prove nothing so long as the conclusions are not verified by experience. Experimental science is the queen of sciences and the goal of all speculation." Usually these expressions are set down as absolutely peculiar to Bacon at this time, and above all as not being held by the great teachers of the period. They are supposed to be portions of Bacon's own conclusions, for which indeed it is sometimes said that he eventually came into disfavor and even had to spend years in prison toward the end of his life.

As a matter of fact, however, the other great university teachers of the thirteenth century had reached similar conclusions. Even Albertus Magnus, whom Bacon so bitterly criticized and to whom the great scholar had once replied that some people wrote nothing themselves but criticized others much, an expression that is often used in the modern time without any thought of the necessity for using quotation marks for it, and referring it to a thirteenth century teacher, often used expressions very similar to these of Bacon. In Albert's tenth book, wherein he catalogues and describes all the trees, plants, and

herbs known in his time, he observes: "All that is here set down is the result of our own experience or has been borrowed from authors whom we know to have written what their personal experience has confirmed; for in these matters experience alone can bring certainty — *experimentum solum certificat in talibus*". Albertus Magnus was a thoroughgoing experimentalist in the best modern sense of the term. He says in the second book of his treatise *On Minerals*, "The aim of natural science is not simply to accept the statements of others, but to investigate the causes that were at work in nature for themselves."

In like manner much is now made, especially in connexion with the celebration of the septicentenary, of Bacon's deprecation of appeals to Aristotle, as if the *ipse dixit* of any master could settle scientific questions. Albert in his treatise *On Physics* was quite as absolute as Bacon ever was, for he said, "Whoever believes that Aristotle was a God, must also believe that he never erred; but if one believe that Aristotle was a man, then doubtless he was liable to err just as we are." [3] In fact, as is pointed out by the *Catholic Encyclopedia* in the article on Albertus Magnus, Albert devotes a lengthy chapter in his *Summa Theologiae* to what he calls "the errors of Aristotle".

[3] *Physica*, lib. viii, tr. 1, xiv.

This does not lessen the merit of Bacon's independence of thought, but it serves to show how grievously modern commentators err who insist that Bacon was either the first to throw off the shackles of authority or the only one to do so, and that his persecution must be referred to this. Saint Thomas Aquinas was quite as ready to seek truth for itself apart from authority as either Albert or Roger Bacon, and so are other great teachers of this period. Indeed it has been well said that there probably never was a time when, within the Christian Church and the schools under its immediate authority, there was so much liberty of thought and even of speculation as well as of teaching, as during the thirteenth century.

Bacon was not the first, but was more complete in his exposition of the reasons for human ignorance, as being largely dependent on trust in authority, than his contemporaries. His famous four grounds for the failure of progress in genuine knowledge among the Latins are true not only for his own time, but for all time. These *offendicula* or stumbling-blocks on the road to knowledge, as Bacon so aptly calls them, are (1) dependence on authority, (2) yielding to established custom, (3) allowing weight to popular feeling, and (4) concealment of real ignorance with pretence of knowledge. It is worth while having them in the original Latin, for they provide an excellent example of Bacon's discriminating use of words: "I fragilis et in-

dignae auctoritatis exemplum; II consuetudinis diuturnitas; III vulgi sensus imperiti; IV propriae ignorantiae occultatio cum ostentatione sapientiae apparentis".

While Bacon thoroughly despised the opinion of the crowd, even going to the extent of declaring that "whatever seems true to the many must necessarily be false", he did not hesitate to emphasize the fact that many of their teachers deserved even more of contempt. He said emphatically that "the common people are not guilty of the fourth fault, concealment of ignorance and assumption of knowledge; that is the peculiar property of the learned professors". He suggests in a very striking expression that authority may compel belief, but cannot enlighten the understanding; in his own words, "credimus auctoritati, sed non propter eam intelligimus". He even ventured to add that, while all honor should be paid to the ancients, those who come later in time having the advantage of the studies of those who went before them, are really often in a position to see more clearly than their predecessors. He has put the thought into the summarized Latin form, "Quanto juniores, tanto perspicaciores — the younger men are, the more acute they are". By younger he meant the more recent in time they are.

Friar Bacon and Mathematics.

I suppose that almost the last thing that could possibly be imagined by most people with regard

to a medieval friar, no matter how scholarly he might be, would be that he should set up mathematics as the great criterion and absolutely indispensable auxiliary of science. This was, however, exactly what Roger Bacon did. He did not hesitate to say in the *Opus Majus:* "For he who knows not mathematics cannot know any other sciences; what is more, he cannot discover his own ignorance or find its proper remedies". He constantly extolls mathematics as the key to all the other sciences. Bacon even went so far as to insist on the value of mathematics as a subject for education eminently developmental of the mind. He dwelt on it as a culture subject, in our phrase, and insisted that no educated man ought to be unfamiliar with the basic principles of mathematical science, in order that he might be able to understand the accuracy of scientific work. Even though there might be no particular use for it in life, the subject ought to be studied.

In our time it has come to be realized more and more that Bacon's expressions with regard to mathematics being so necessary for any true development of science, are quite literally true. Without mathematics many of our great advances in modern science would have been lost. Poincaré, the great French mathematician who died prematurely during that seven-hundredth anniversary of Bacon's birth in 1914, once declared: "If we had not cultivated the exact sciences for themselves, we should not have created mathematics the instrument, and the day

the call came from the physicist we should have been helpless." More than fifteen years ago the English mathematician and physical scientist, Professor Kingdon Clifford, did not hesitate to say: "No advance seems likely in molecular physics until more mathematics is invented." It is only after reading expressions of this kind from the mouths of our greatest modern mathematicians that the prophetic wisdom of Bacon's opinions to the same effect, proclaimed nearly seven hundred years ago, can be properly appreciated.

The one tangible result of Bacon's own work in mathematics is his extremely close approximation to the actual correction needed in the Julian calendar. In the *Opus Majus* in 1267 he tried to make it clear to Pope Clement IV. that the length of the year of the Julian calendar is too great by one day in 125 years. This is a very startling declaration at that time, for the best known calculations of a few years before, the Tables of Alphonso, asserted that the error was one day in a little over 134 years. We do not know how Roger Bacon reached his much closer approximation to the actual error than any known to have been suggested before his time. The fact, however, that he did so is the best possible tribute to his personal powers as a mathematician. He not only recognized their value in theory, but he was capable of practising them to a more accurate degree on the most im-

portant problem then before mathematicians than any man up to his time.

As to Roger Bacon's place in mathematical history, the only way to give an authoritative opinion on it is to quote Professor David Eugene Smith's (of Columbia) concluding paragraph on the subject in the Commemoration Essays, in which he answers the question as to whether Bacon deserved the title sometimes given him of *doctissimus mathematicus* or not. As Professor Smith is a recognized authority on the history of mathematics, his opinion has compelling weight.

> No one in his generation, few men in any generation, certainly no man in medieval England, showed such sympathy with mathematics, such familiarity with the standard authors available, such clear perception of the possible applications of the science, and such conviction of the value of the subject in a liberal education. Jordanus was his superior in detail, but was relatively a pigmy in general power; Albertus Magnus seemed to accomplish more in physics and chemistry, but Roger Bacon gave a formula which freed intellect from brute force—the formula for gunpowder. Alexandre de Villedieu and Bartolomeo de Parma were better known in astronomy; but it was Bacon's computations which gave to the Middle Ages the best calendar as yet devised, and which led him to set forth with perfect assurance the possibility of circumnavigating the globe. It is not for his treatises nor for his discoveries in the realm of pure mathematics, but for his appreciation of the science, for his knowledge of what the world had done, and for his vision of what the future had in store, that for seven centuries he has borne with justice the title of *doctissimus mathematicus*, a title

by which he may rightly be known even in our own time and in the centuries to come.

Medical Excursions.

Bacon's writings with regard to medicine are very interesting to our generation, because his passion for exactness, the same that made him so devoted to mathematics, led him to try to make physicians see that they should reduce their treatment of patients to an exact science. In a fragment of his *De Graduacione Medicinarum* he insists, practically in Plato's words in the Philebus, that "Arithmetic, mensuration, and weighing being taken from any art, the rest will be only conjecture". Bacon realized that the dependence on the patient's feelings, to which the physician was subjected, made accurate diagnosis and still more accurate treatment extremely difficult; but he indicated that this was the line along which real scientific advance in medicine might be expected. Two centuries later, as I have pointed out in my *Old Time Makers of Medicine*, Cardinal Nicholas of Cusa not only emphatically made the same suggestion, but he went further and indicated just how something might be done in a practical way. His basic idea in the matter, as may be seen from the sketch of him in this present volume, was that the comparative weights of blood and other fluids in the body at various times in life and under varying conditions of health would furnish significant information to physicians, as of course they have.

Physicians are slow to give up theories that seem to explain so much, for minutiæ of information which at all times seem at first to mean so little. The medical profession has always been conservative, and necessarily so, since human lives are the subjects of their experiences. It is not surprising, however, that Bacon, looking over the field of medicine in his time and recognizing its lack of foundation on experiment, should have been tempted to write his *De erroribus medicorum*, On the Errors of Physicians. Dr. Withington, the English authority on the history of medicine, who wrote the article on Roger Bacon and Medicine for the Oxford Commemoration Essays volume, declares this to be "perhaps the most interesting originally typical and Baconian of the Friar's Medical Treatises".

Bacon criticizes rather severely the physicians of his time for not basing their practice on experience. He begins by saying that there are thirty-six great and radical defects in the medicine of the time, but with infinite ramifications. After describing seven of these defects, however, he confesses his inability to go on because he has not the experience that would enable him to obtain certitude. Curiously enough, while insisting so much on experience, he himself depends very much on the Arabs, and probably nothing shows so well how little the Arabs brought either to science or to medicine than the fact that Bacon's dependence on them, because the great Greek authors whom the Arabs were supposed to rep-

resent were not available for him, led him into many rather serious fallacies. Above all, he spoke of Avicenna as *dux et princeps philosophorum,* makes him his chief guide in medical matters, quoting him as frequently as all other authors combined. When the history of medicine began to develop under Haller in the eighteenth century, Haller did not hesitate to characterize the great Arab philosopher's work, in so far as it touched medicine, as "methodica inanitas", which I suppose might be translated as "inanity with a method in it". The expression is perhaps too strong, but it is ever so much nearer truth than Bacon's inordinate praise.

By the irony of fate Bacon allowed himself to be carried away by the very human tendency of respect for authority into over-dependence on this Arab master in medicine. Sometimes even here, however, his genius of intuition leads him right. He has emphasized from Avicenna the description of the patient who was cured of consumption by using large amounts of sugar. Sugar is one of the dietetic elements which we have come to recognize in modern time as valuable for the increased nutrition, which is the most important part of the treatment of tuberculosis.

The favorite idea of Bacon's was that health was quite as contagious as disease. This is sometimes thought to be a very modern suggestion. Bacon seems to have believed quite literally in it. He actually thought that the old received new

stores of health and strength by associating intimately with the young. He describes a *fumus juventutis*, that is, a certain exhalation of youth, as it were, which, entering into the bodies of the old, by its very contact puts new life in them. Curiously enough, as pointed out by Withington in the Commemoration Essays, Sydenham, who in the late seventeenth century wrote so well on medicine that he has been given the title of the English Hippocrates, emphasized the same idea, though evidently rather hesitant as to its practical applications. A good many physicians in our time have pointed out that there is nothing which so serves to keep the old young as intimate association with young folks. There is a sort of instinct in the matter which often makes the grandfather a more sympathetic companion to the growing boy than his own father.

Bacon was as much interested in the question of the retardation of old age as any of the modern scientists. There is a monograph from him, *De retardandis senectutis accidentibus*, "On the Putting Off of the Accidents of Old Age" which is written quite in the temper of Metchnikoff's book of a similar character in our time. Of course most people would be quite sure that anything that Bacon might have to say on the matter would be of very little significance, while Metchnikoff's ideas would be worthy of deep consideratiton. However that may be, for there are some skeptical spirits in our time who are not quite sure that Metchnikoff's ideas, especi-

ally those with regard to sour milk, though given such wide publicity by moneyed interests engaged in the manufacture of a particular brand of sour milk, are of any very great value, one thing is certain, namely, that Bacon very probably lived to be well beyond eighty years of age, while Metchnikoff died before he was seventy. At least, Bacon's practice of the rules necessary to secure long life would seem to have been more successful than his modern scientific colleague, who presumably knew so much more about it. Bacon probably outlived also most of those who so sedulously, under Metchnikoff's direction, swallowed the *bacillus bulgaricus* of the only genuine Balkan sour milk and its products in our time for the purpose of reaching old age.

The thirteenth-century scholar appreciated cordially the influence of the mind on the body and even states very clearly his conclusions, evidently obtained from personal observations of various kinds in this matter. It is so often presumed that it is only in comparatively recent years that men have come properly to appreciate the significance of mental influence in the cure of disease, that a paragraph from Bacon on the subject becomes very interesting reading.

Figures and charmes[4] may sometimes be used by physicians with good effects; not from any prevalency

[4] By figure, Bacon meant an astrological calculation of any kind and by charme he meant anything popularly supposed to have magical influence.

in them, but that the raising of the soul is of great efficacy in the curing of the body, and raising it from infirmity to health by joy and confidence may be done by charmes; for they make the patient receive the medicine wth greater confidence and desire, in exciting courage, more liberal belief, hope and pleasure.

Even the most fervid of psychotherapeutists in the modern time would be quite satisfied with that expression.

Utility in Education.

How little human ways of looking at things change even in what may seem comparatively so long a period as seven hundred years, can be readily seen from some quotations from Roger Bacon on the subject of education. If there is any subject in which men should be making definite intellectual progress, surely it is that in which they are consciously occupying themselves with the problem of making the rising generation more intelligent than its predecessor, and yet we have been treated in recent years to arguments *pro* and *con* about education, strangely reminiscent of Bacon's expressions on the subject. In our time there has been a recrudescence of the view that the great underlying question is the utilitarian element in educational systems. Of what use is a particular subject or phase or method of education? What is it worth for life, and for the making of a living? In the fourth chapter of his *Opus Tertium*, Bacon has a series of expressions with regard to education along

these lines which make it very clear that what a great many people say at the present time, quite confident while they say it that they are expressing a new idea that has come to the world as a consequence of our noteworthy progress in recent years, is after all only a repetition of some of the oldest phrases that we know in educational controversy.

Bacon, for instance, says: "But because men are ignorant of the primal utilities of philosophy, therefore they despise many magnificent and most beautiful forms of knowledge, and ask, 'What is this or that science worth?' ridiculing it and insisting that they shall not learn it." There is another expression, which makes Professor David Smith in his article on "The Place of Roger Bacon in the History of Mathematics", in the Bacon Commemoration Essays, say: "How history repeats itself!" Bacon wrote: "For students in these days when it is said to them that they ought to know optics or geometry or languages or a number of other things, ask in derision, 'What are all these worth?' They assert that they are quite useless, and they do not wish to hear any discourse as to the true meaning of utility, and as a consequence they neglect and despise sciences of which they know nothing."

We are in the midst of a renewal of the controversy over the value of the classics and the sciences as basic elements in education, and some of those in favor of science who are loudest in

their public expressions seem to think that in utility they have discovered a new touchstone of values in education. It might be worth their while to go back and read the fourth book of Roger Bacon's *Opus Tertium*, so as to help their historic background.

Roger Bacon and Francis Bacon.

Inevitably, even though comparisons may be odious, a comparison between Roger Bacon and his namesake, Francis Bacon, suggests itself. The fate of the two men was very different in the generations that succeeded them. Francis Bacon came to be looked upon by many as one of the greatest intellectual geniuses that the world has ever known, and not a few hailed him as the father of modern inductive science. Roger Bacon, on the other hand, came, within a few generations after his death, into the bitterest of contempt and was looked upon as a typical example of the supremely foolish conceit of knowledge without any real basis for it which was at least supposed to be characteristic of the Middle Ages. His name became a popular subject of satire, a favorite symbol of utter pretentiousness and lack of true knowledge. This continued for nearly six centuries before the whirligig of time began to bring in its revenge.

Now for some generations Francis Bacon has been gradually losing in prestige until it is rather generally considered that he was a much-overrated man, who came at a period of transition in

the world's history and who formulated certain ideas that had been expressed by geniuses of the time just before his own, especially such men as Bernardino Telesio, the Italian philosopher, of whom it has been said that his work "marks the fundamental revolution in scientific thought by which we pass over from the ancient to the modern methods". His work was done nearly 100 years before that of Francis Bacon. Perhaps the best evidence for the limitations of Francis Bacon's mind is to be found in the fact that he refused to accept the Copernican theory nearly a century after Copernicus's death, because he thought that the old Ptolemaic theory solved the difficulties better.

While Francis Bacon's sun has been setting, Roger Bacon's fame has been growing ever more and more. Indeed it was only the lack of knowledge of the work done on the Continent that gave Francis Bacon the place he holds in English literature. In all that concerns the inductive method in science he had long been anticipated by the medieval Roger Bacon. Even English authorities in the history of science began to acknowledge this rather freely a generation ago, and now it is very generally recognized by all who know whereof they speak.

Huxley once said, "To hear people talk about the great Chancellor — and a very great man he certainly was — one would think that it was he who had invented science and that there was no such thing as sound reasoning before the time of

Queen Elizabeth." Even Professor Draper here in America, so often utterly ignorant of the history of science before our time as he showed himself, could not find anything good to say of Francis Bacon. "The more closely we examine the writings of Lord Bacon," he said in his *Intellectual Development of Europe*, "the more unworthy does he seem to have been of the great reputation that has been awarded to him. . . . This boasted founder of a new philosophy could not comprehend and would not accept the greatest of all scientific discoveries when it was plainly set before his eyes." Draper refers, of course, to Francis Bacon's rejection of Copernicanism, though he might have referred also to his contemptuous depreciation of the work of Gilbert of Colchester, the great physician-founder in electrical science who was elected the President of the Royal College of Physicians in England for the year 1600, and whose work *De magnete* is one of the most significant early contributions to modern experimental science.

In the memorial volume of Essays on Roger Bacon there is a story of one of the eminent editors of the works of Francis Bacon over half a century ago in England being attracted to the works of the medieval namesake of the more modern English scientist and Lord Chancellor by the name. To his surprise he found the older Bacon of the Middle Ages so interesting for himself that he went on and read his works for their own sake. After doing so, he said to Dr. Whe-

well who was just then writing his work on *The Philosophy of Discovery*, "I have lately been reading some of Roger Bacon's writings and I am inclined to think that he may have been even a greater man than our Francis Bacon." Whewell's own opinion of Bacon, as expressed in his *History of the Inductive Sciences*, though he confessed that he knew him from the *Opus Majus* alone, is summed up in his description of that work as "the Encyclopedia and the Novum Organon of the thirteenth century". He felt that the modern Bacon had been anticipated by his medieval namesake.

Bridges, the learned English editor of Bacon's works, has suggested a contrast between Roger Bacon and Francis Bacon that is very striking and all the more significant for us because in all that is solid and serious in intellectual values it favors the medieval rather than the modern scientist.

> Between the fiery Franciscan doubly pledged by science and by religion to a life of poverty, impatient of prejudce, intolerant of dulness, reckless of personal fame or advancement, and the wise man of the world, richly endowed with every literary gift, hampered in his philosophic activity by a throng of dubious ambitions, there is but little in common. In wealth of words, in brilliancy of imagination Francis Bacon was immeasurably superior, but Roger Bacon had the sounder estimate and the firmer grasp of that combination of deductive with inductive method which marks the scientific discipline. Finally, Francis Bacon

was of his time; with Roger Bacon it was far otherwise.

Modern Appreciation.

Undoubtedly the most interesting phase of the recent renewal of interest in Roger Bacon lies in the fact that men of so many different kinds of scholarship and culture, Jew and Gentile and Christian, philosopher and scientist, physician and philologist, have found so much to admire in him. For the better part of a century now he has been coming back into his own proper meed of appreciation. It is quite easy to find tributes to him in every language in Europe, and the volume of Commemoration Essays was actually printed in three languages—French, German, and English. A collection of books on Roger Bacon written during the past two generations would now probably occupy even more than "a five-foot shelf".

Victor Cousin, about the middle of the nineteenth century came to appreciate very thoroughly something at least of Bacon's wonderful genius. He suggested that it would be a worthy work of scholarship for an English fellow-countryman of Oxford or Cambridge to write a sketch of Bacon giving his place in relation to his time. England was not interested in the Middle Ages at that moment. Her scholars were mainly occupied with the early centuries of Christianity, and the Oxford Movement was under way. It was a French pupil of Cousin himself,

who took up the suggestion of his master and gave us the first important modern account of the great medieval philosopher-scientist.[5]

Cousin's suggestion to English scholarship did not bear fruit until well on toward the end of the nineteenth century, when Dr. Bridges wrote his sketch of Bacon's life and edited the *Opus Majus*. The motive that prompted him to do so is clearly stated at the beginning of the Introduction. The paragraph serves to emphasize how much the thirteenth-century philosophy had anticipated the viewpoint of nineteenth-century thinkers. Dr. Bridges, himself a Positivist and close disciple of Comte, felt that Bacon had anticipated even his master.

> The *Opus Majus* when published in its entirety appears to me to present to the world a scheme of culture, contrasting strongly with any that was offered in Bacon's time or in the centuries that followed, combining as it does the comparative study of language with a comprehensive grasp of physical science, conceiving these studies as progressive and yet holding them subordinate to a supreme ethical purpose.

Dr. Bridges does not hesitate to say that it was not until the time of Comte that anyone came to give the world a philosophic and scientific presentation of the meaning of life, such as we have from Bacon. Comte, I need scarcely say, would be for Dr. Bridges, as for so many others

[5] Roger Bacon, Sa Vie, Ses Ouvrages, Ses Doctrines, d'après des texts inédits, Paris, thesis 1851, Émile Charles.

of his devoted followers, the very last word in applied philosophy.

Bacon's appreciation broadened with the years after this. S. A. Hirsch, whose volume, *A Book of Essays*, published under the patronage of the Jewish Historical Society of England, contains a study of English Hebraists and other Hebrew scholars throughout Europe, felt constrained to add his words of appreciation of Roger Bacon's knowledge of Hebrew at a time when that language was little known in the West. "I am of the opinion," he says, "that the direct evidences of Bacon's knowledge of Hebrew contained in his works do less than justice to him. His own testimony as to his proficiency in that language cannot be lightly set aside. He describes himself as a zealous student of Hebrew who had studied the subject for a number of years. He declares that, although he referred elsewhere to his knowledge of Arabic, yet he did not write it like Hebrew, Greek, and Latin. Bacon was not an idle boaster, and full credence is due to assertions of that kind."

Dr. Hirsch, whose book of essays contains articles on Pfeffercorn, Reuchlin, and others which show very clearly how competent he is in this matter of early Hebraists, feels sure that Bacon wrote a Hebrew grammar just as he did a Greek Grammar, though unfortunately only the Greek Grammar has been preserved. This study of Hebrew at that time when the language was of comparatively little interest to scholars gener-

ally, shows at once the breadth of Bacon's interests and at the same time his unappeasible desire to get at sources, as well as his readiness to take any amount of trouble in order to do so.

On the other hand, the breadth of Bacon's human sympathies can be very well appreciated from a passage in his writings quoted by Hirsch, in which Bacon expresses his feelings with regard to the existence of many good Jews at the time of the Crucifixion who rejected Christ. For Bacon declared that he felt that there were at the time of the Crucifixion many holy and good men among the Jews; and nevertheless they all rejected the Lord, except His Mother and John and the Marys: nay, it is even said that nobody really believed in Him except His Mother. His expressions show at once his own tolerance, which went to an extent quite unusual at that time, though the feeling toward the Jews voiced by Innocent III, the great Pope who was in the pontifical chair when Bacon was born, had done much to foster a new liberality of spirit toward the Jew. What is more significant for us is that Bacon's words reveal that feeling toward the Blessed Virgin and her position in relation to her Son which was so profoundly reverent at this time and is noteworthy in the writings of St. Thomas Aquinas and of Duns Scotus, the great English Franciscan scholar of the next generation, whose conclusions with regard to the Immaculate Conception have since proved to be the mind of the Church.

Every phase of Bacon's work has come to be appreciated in our time. In the Commemoration volume there is an essay by Cardinal Gasquet on "Roger Bacon and the Latin Vulgate", in which that great historian does not hesitate to say: "Bacon's proposal to Pope Clement IV was to appoint a commission of capable men with the avowed object of restoring the text of St. Jerome. The methods he suggests are the scientific methods employed to-day in the production of a critical text." His concluding sentence is: "What must strike any reader of Roger Bacon's works in regard to the Holy Scripture is the grasp the learned doctor had in the thirteenth century of the whole subject of Biblical revision, and how true and clear were the critical principles he laid down so many centuries ago."

Bacon's "Imprisonment".

Like many other genius, Roger Bacon was not very amenable to discipline nor prudent in the control of his pen and tongue. He was typically one of those who in religious Orders, where individuality must to a great extent be submerged in the community, is likely to make himself and others uncomfortable. This, of course, supplies opportunities for both parties to make progress in sanctity, though that phase of the problem is only properly appreciated afterward and at the moment often has no special appeal. Above all, Bacon was, as we have seen, too much inclined to indulge in personalities sometimes at the ex-

pense of members of his own Order, for he never for a moment hesitated to criticize severely Franciscans with whom he disagreed, and occasionally even his own superiors came in for a thrust from his biting tongue. What was rather more serious, he permitted himself to say and write the bitterest things with regard to members of the brother religious Order, the Dominicans. This caused a good deal of scandal, and the Franciscans who seem to have borne with Bacon's bitterness when it concerned only themselves felt compelled to take condign notice of it.

It was these unfortunate personal elements in Bacon's disposition that prevented him to a great extent from having the full amount of influence in his own time that he might otherwise have had. What Professor Smith says of Bacon's judgment of the mathematics of his day, as "one of profound and vociferous contempt", might very well be repeated with regard to nearly every subject in which Bacon had done special work until he felt the consciousness of knowing more about it than those around him. There is no doubt at all that much of the mathematical teaching deserved his profound contempt, but there was no need of his vociferousness in condemning it so scornfully. This bitterness only aroused opposition and hardened men into the maintenance of their opinions. This is always the fault of the destructive rather than the constructive criticism.

Professor Smith's paragraph as to Bacon's opinion of the mathematics of his contemporaries can be applied to practically every feature of Bacon's mode of regarding his university colleagues. He said: "Indeed, it is in the expression of this contempt that we find one cause of his failure to influence the education of his time as much as might have been expected from his learning and undoubted ability. Instead of soberly going about the work of construction, he raves about the shortcomings of most of his contemporaries. For a follower of the lovable St. Francis of Assisi, he was filled with a bitterness that is hard to explain, and that militated against his success, not merely among his contemporaries but for at least three centuries after his death."

Bacon's acerbity of character, often so typical of genius, was sure to get him into trouble sooner or later. He was impulsive and quite sure that all the world was wrong except himself, and the world does not accept that sort of judgment very readily. He was a man far in advance of his time, which gave cause enough of itself for lack of sympathy from his fellows, but besides he was utterly impatient of others and, as can be seen from his writings, rather petulant and prone to indulge in personalities when an exposition of the subject in hand would have been much better and might have been even irenic. When his petulance involved the Dominicans, his superiors had to take notice of it. The members

of the two great religious Orders, which had been founded about the same time in the preceding generation, were brought into intimate contact at the Universities of Oxford and Paris. They had sometimes allowed themselves a liberty of criticism in intellectual matters that degenerated into personal bitterness, until secular students and pupils had been disturbed and even serious scandals occasioned. What Voltaire called in his cynical way *la jalousie du couvent*, has not infrequently had a tendency to degenerate into unfortunate and even scandalously strained relations between members of different Orders, because after all even religious are only men, and humanity is envious and jealous by nature and the old Adam dies hard. This fact only makes it all the more incumbent on religious superiors to discipline even severely, at least the most serious offenders in this important matter involving infractions of Christian charity, among those supposed to be most devoted to its practice.

It is no wonder that when a reaction came in the Franciscan Order, Bacon was put in enforced retirement. It is doubtful whether anything more than this can be said of what has been called his "imprisonment", and that some people have been inclined to think of as twenty or thirty years of confinement to a dungeon. It is like Galileo's imprisonment. The good Florentine mathematician and astronomer was never in prison for an hour. He was confined to the home of a Cardinal friend, but that was one of

the palaces of Rome where any of us would be quite willing to be entertained while at the Papal Capital. The main portion of Galileo's punishment, poor fellow! was to say the Seven Penitential Psalms every day for three years. He was placed in charge of a Jesuit friend in his own house, and later his guardian, that is, his "jailor", to use the word of Protestant controversy,—selected for him by the Roman authorities,—was his own son.

Roger Bacon was imprisoned, not by the command of the Church, but the "Minister General of the Order of the Franciscans", Jerome of Ascoli, who was afterward Pope Nicholas IV. We know his career as a Pope very well, and his character was the farthest possible removed from the type of intolerant medieval churchman he would have to have been if ordinary Protestant traditions with regard to Bacon's imprisonment at his command were true. Jerome of Ascoli was the first of the Franciscans to be chosen as Pope and declined the honor, being finally forced to accept it under obedience after a second election. He was one of the gentlest of men. As a matter of fact, the records show that it was only "on the advice of many of the Franciscan brethren that the doctrines of the English Brother Roger Bacon were condemned and rejected."

According to the *Chronica*, Roger was "imprisoned". Just what this imprisonment [6] con-

[6] This whole question of imprisonment for religious, and just what it consisted of, has not as yet been

sisted of for members of religious Orders is not very clear. There is no question at all that they were thrown into an ordinary prison. Some portion of the monastery in which they had been living or some special monastery was assigned as their living quarters. They were expected to say Mass every day, if they were priests, or to hear Mass daily, if they were not priests. Their freedom was restricted, and perhaps they were not allowed to leave a small garden near the house. Very probably the diet of the "imprisoned" was quite limited, but then in the early fervor of the Franciscans a very restricted diet was a very usual thing. Certainly, Bacon's health does not seem to have been hurt in any way. The assertion of many modern writers that Bacon was imprisoned fourteen or fifteen years is quite gratuitous, and has no foundation

worked out. There are frequent references in the old religious chronicles to the imprisonment of religious for violation of their rules *contumaciously*, and above all for repeated violations of charity. How far this went as actual punishment beyond the stigma that for a moment was placed on a religious among his Brothers of the Order, is not clear. As a rule religious Orders are careful not to injure a man's usefulness among seculars by allowing any Order punishments to be generally known. They were rather careful of the reputation of their members. It is indeed sometimes said that their *esprit de corps* made them over-careful. Whatever imprisonment Roger Bacon suffered was entirely within his Order and does not seem to have created in him, so far as we know, any feeling of resentment.

in ancient sources. Its frequent repetition is due entirely to over-zeal in proving the Church's persecuting tendencies, though the Church as such had nothing at all to do with the matter.

At the end, all we can say is that here was a great man of genius. He was, however, a man, as well as a genius, which is as much as to say that necessarily he had his faults—and indeed in geniuses these are usually emphasized. Bacon's wonderful power of penetration enabled him to see far below the surface of things to truths that were to be revealed with assurance only to scholars long after his time. Men of his type are the demonstration that at any time men who "have the mind to", in both senses of the expression, are capable of facing the problems of humanity and the universe and at any time seeing the answers as clearly, though not in as much detail, as the progress of knowledge may later permit, as at any other time. It is the man, not his time, that counts; his intellect, not the extent of his knowledge. Fortunately for him, Bacon's lot fell in happy conditions, where for forty years he could devote himself to study almost without distraction. The difficulties that came to him at the end of his life were largely of his own making, and they must not have disturbed him very seriously, since he probably lived on to be nearly four-score of years and perhaps more.

III.

CARDINAL NICHOLAS OF CUSA.

THE Roman Catholic Church then, as now, was a great democracy. There was no peasant so humble that he might not become a priest, and no priest so obscure that he might not become Pope of Christendom, and every chancellery in Europe was ruled by those learned, trained and accomplished men—the priesthood of that great and then dominant Church; and so, what kept government alive in the Middle Ages was this constant rise of the sap from the bottom, from the rank and file of the great body of the people through the open channels of the Roman Catholic priesthood.

—PRESIDENT WOODROW WILSON, *The New Freedom.*

THERE has always, in generous souls who have some tincture of philosophy, subsisted a curious kind of sympathy and yearning over the work of these generations of mainly disinterested scholars who, whatever they were, were thorough and, whatever they could not do, could think.

—SAINTSBURY, *The Flourishing of Romance and the Rise of Allegory.*

In necessariis unitas, in non necessariis libertas, in omnibus caritas.

III.

CARDINAL NICHOLAS OF CUSA.

THE career of Roger Bacon presents a most interesting but very striking contrast to that of Cardinal Nicholas of Cusa, whom we have chosen to follow him in this volume. Both lived their lives in the Middle Ages, the Cardinal dying just about ten years after the fall of Constantinople, which is usually set down as the end of the medieval period. Roger Bacon in the thirteenth century was assuredly possessed of a greater scientific mind than the distinguished Cardinal of the fifteenth century, and yet the Cardinal was undoubtedly a man of profound learning and science in his time, and had he lived out his four-score years as Bacon did, might have left behind him works that would have attracted scarcely less attention. As it is, Nicholas of Cusa represents one of the important links in that chain from the thirteenth-century scientists to the Renaissance time which culminated in Copernicus's revolutionary theory and the beginning of modern astronomy; and he is himself a great pioneer in that Renaissance of science as well as of art that occurred in the fifteenth century.

The difference in the fate of these two men, Bacon and Nicholas of Cusa, is extremely interesting. Bacon toward the end of his long life

had just been released from an imprisonment of some kind, which was perhaps not very strict, but which deprived him of his liberty and represented his condemnation by his ecclesiastical superiors; while Nicholas of Cusa was the Bishop of Brixen, a Cardinal of the Holy Roman Catholic Church who had been very frequently sent as the Papal legate to various portions of Europe. Cusanus, as he was called after the fashion of the day in Latinizing names, was one of the most highly honored of ecclesiastics of his time, and while he too had been in prison for a period, this was not due to any effort on the part of ecclesiastical authority to suppress his very liberal scientific speculations, but to Duke Sigmund, his civil ruler, who hoped thus to obtain from the Cardinal Bishop of Brixen the abrogation of certain Church rights and privileges.

The secret of the difference in the life histories of the two men is undoubtedly one of personality. Roger Bacon was by no means an easy man to get along with, critical to the highest degree and perfectly certain that those who did not agree with him and his opinions must be either foolish or insincere. He bitterly abused distinguished scholars of his own time, some of them belonging to the Franciscans, but more of them to the Dominicans; and this was looked upon as an abuse of charity that must be prevented at all hazards. Nicholas of Cusa was a man of gentle and kindly character, diplomatic in his relations with others, sagacious and firm in his recognition

and correction of abuses, but with an endless fund of sympathy for human nature and above all for those who did not happen to see things as he saw them. While the one found himself in dishonor, the other added honors to honors, until the very end of his life.

It is this personal element that has been only too often forgotten in the stories of the careers of men of science who supposedly have been persecuted by Church authorities, but who really owed their persecution to personal characteristics that made it extremely difficult for anyone to get along with them. This applies very well to other cases than Roger Bacon's, as, for instance, to that of Giordano Bruno, whose life follows that of Cusanus in the next century. Now that we are having serious troubles with anarchists ourselves, we are beginning to be able to understand how disturbers of social order may find themselves outside the pale of the law mainly because they offend the sense of a time. Our experience with cranks of many kinds during the war has been an illuminating lamp of history, if we will but use it as such.

The story of the life of Nicholas of Cusa, or as he was called, following the custom of the Renaissance time which took the Latin name of a man's native place and made an adjective of it, Cardinal Cusanus (so characteristically exemplified in the case of Regiomontanus, about the same time), is interesting not only for his personality, however, but because he was one of the great

men of a great time in close touch with his distinguished contemporaries. He was a particular friend of Toscanelli, the well-known physician and scientist whose writings so deeply influenced our own Columbus. But it must not be thought for a moment that Nicholas was a narrow student of physical science. On the contrary, he was rather famous as a scholar in a scholarly time, knowing Latin and Greek and Hebrew well, and in later years Arabic; and he was a particular friend of Æneas Sylvius Piccolomini, that distinguished pioneer in the New Learning who afterward became Pope Pius II. Probably no churchman of the fifteenth century is more thoroughly representative of the Church before the Reformation came to disturb Europe than this son of a German tradesman who rose to be one of the most important characters in the civilized world of his time.

Nicholas of Cusa is a striking example of that acute expression of President Wilson in one of the addresses of his book *The New Freedom*, in which, recognizing sympathetically the great saving element of democracy in the Middle Ages and the chance that this afforded many a man to rise in life, he pays worthy tribute to it.

> The only reason why government did not suffer dry rot in the Middle Ages, under the aristocratic systems which then prevailed, was that the men who were efficient instruments of government were drawn from the Church, from that great Church, that body which we now distinguish from other Church bodies as the

Roman Catholic Church. The Roman Catholic Church then, as now, was a great democracy. There was no peasant so humble that he might not become a priest, and no priest so obscure that he might not become Pope of Christendom, and every chancellery in Europe was ruled by those learned, trained and accomplished men—the priesthood of that great and then dominant Church; and so, what kept government alive in the Middle Ages was this constant rise of the sap from the bottom, from the rank and file of the great body of the people through the open channels of the Roman Catholic priesthood.

Early Life and Education.

Nicholas, who was destined to become one of the most prominent men in Europe before his comparatively early death at sixty-four, was born in an obscure little town of the Rhineland called Cues, and it is the Latin form of this name of his native town, Cusa, that now designates Nicholas in history. His father was a tradesman, probably a boatman by the name of Krebs, reasonably well-to-do, perhaps even wealthy for the community in which he lived, but for some reason, perhaps miserliness, making life at home very uncomfortable for his son. According to a tradition, which however is not well substantiated, Nicholas fled from the ill-treatment of his father to Count Ulrich of Manderscheid, to whose good-will he owed his opportunities for the higher education. That is a point of history that will probably never be decided now. His father seems to have provided for his early education with the Brothers of the Common Life at

Deventer, and this of itself was quite sufficient to give him an excellent opportunity in life.

Many another distinguished thinker of the fifteenth and sixteenth centuries received his introduction into the intellectual life from these good Brothers of the Common Life. Among them, besides the immortal Thomas à Kempis, were such men as Desiderius Erasmus, the great classical scholar of the Renaissance, whose influence was felt everywhere throughout Europe from England to Italy, Jacob Wimpheling, who has often been hailed as the schoolmaster of Germany, "*Preceptor Germaniae*," Agricola and Alexander Hegius, the humanists, John of Dalberg, and many others. Deventer, where Nicholas of Cusa studied in his earlier years, counted some 2,000 students, it is said, about the time of the discovery of America. I have told the story of the Brethren briefly in a chapter in *The Century of Columbus* under the title, "The Scholarship of the Teutonic Countries". So far from Nicholas of Cusa being a solitary phenomenon of genius among their pupils, he is only one of nearly a dozen men who attained distinction during the fifteenth and early sixteenth centuries and who owed their youthful training, for which they remained forever grateful, to the humble simple Brothers of the Common Life. To rub out what their students accomplished from the intellectual life of Europe at this time would be to leave a very sad and wide lacuna in the history of European mentality. The late Hamilton

Mabie in his series of essays, *My Study Fire*, has a paragraph with regard to the education given by these Brothers of the Common Life which will perhaps make clearer than anything that I could say the meaning of their educational institutions. It will give the best idea of the influences that surround Nicholas's school days.

> I confess that I can never read quite unmoved the story of the Brethren of the Common Life, those humble-minded patient teachers and thinkers whose devotion and fire of soul for a century and a half made the choice treasures of Italian palaces and convents and universities a common possession along the low-lying shores of the Netherlands. The asceticism of this noble brotherhood was no morbid and divisive fanaticism; it was a denial of themselves that they might have the more to give. The visions which touched at times the bare walls of their cells with supernal beauty only made them the more eager to share their heaven of privilege with the sorely burdened world without. Surely Virgil and Horace and the other masters of classic form were never more honored than when these noble-minded lovers of learning and of their kind made their sounding lines familiar in peasant homes.

The schools of the Brothers of the Common Life afford the most striking evidence in contradiction of the often-asserted neglect of education in Germany before the Reformation. All through the Rhineland and in the Low Countries these simple, devoted scholars gave themselves to the education of the middle and lower classes of the population with wonderful success. They repre-

sented preparatory schools for the universities of the time, and the profound interest in even the highest education in Germany at this time will be best appreciated from the fact that altogether some seven new universities were founded in Germany during a little more than half a century before the beginning of the Lutheran movement. This is all the more interesting because at most two or three new universities were founded during the hundred years after the Reformation, and Professor Paulsen of the University of Berlin did not hesitate to quote with approval Erasmus's expression with regard to the influence of the Lutheran movement on education that, "wherever Lutheranism reigned there was an end of good letters".

How deeply Nicholas was influenced by his teachers at Deventer, so that his whole mode of thought was tinged by their teaching, will perhaps be best recognized from the remark of a critical reader of his popular treatises on theological subjects as they were written late in life. Scharpff calls the theology of Nicholas of Cusa, as it is to be found in books of his written for the faithful on such subjects as *De quaerendo Deum*, "The Quest for God", *De filiatione Dei*, "The Sonship of God", and *De visione Dei*, "The Vision of God", Thomas à Kempis in philosophical language. As Thomas à Kempis probably represents more completely the deep religious feeling of the Brethren of the Common Life than any other, the enduring direction

given to the great pupil's thought will be readily appreciated. At the same time the kinship of his writings with à Kempis is the best possible demonstration of their orthodoxy, though sometimes it has been suggested that there were certain pantheistic tendencies in Nicholas's philosophy.

After his studies with the Brethren of the Common Life, at about sixteen years of age he was matriculated in the University of Heidelberg. His ambitions were high, however, and so in the following year, 1417, he transferred his university work to Padua. It was rather easy to do this at that time, because all the universities were under Papal charters and the exchange of professors and students for the benefit of broader scholarship was greatly facilitated. He graduated as Doctor of Canon Law at Padua in 1423. What probably influenced his life, that is, at least his intellectual life, more than anything else was his meeting at Padua with Paolo Toscanelli, who was afterward to become so well known as a physician and a scientist, and whose influence over Columbus made him famous in the modern time.

While he studied as a clerical student at Padua, he does not seem to have determined absolutely to take priestly orders until somewhat later. He had studied Civil Law as well as Canon Law, and his knowledge of civics was so well known that some years later Bologna gave him the Doctorate in Civil Law. He seems indeed at first to

have thought of practising law as a profession, but was turned from that idea by some experience in an actual lawsuit in which he recognized the pitfalls of legal procedure and the difficulty of securing justice, sometimes at least, without putting forth efforts that to him seemed of questionable integrity. He lost a lawsuit in Mainz shortly after his return from Padua, and then under the patronage of the Archbishop of Trier he matriculated in the University of Cologne for the degree of Doctor of Divinity. He received his doctorate, and the Archbishop recognizing his ability gave him commissions of different kinds at various places in Germany, mainly for the correction of religious abuses.

He came prominently before the Catholic world when, only a little more than thirty years old, at the Council of Basel, and though he pleaded two losing causes there — one of them that of Count Ulrich of Manderscheid, the adoptive father of his youth, to whom he felt he owed a great deal, and the other that of the German nation against the Bohemians — he attracted wide attention for his scholarship and legal ability. The Council was under the presidency of Giuliano Cesarini, the celebrated Italian authority of the time on jurisprudence, who had been Cusa's professor of jurisprudence at the University of Padua. One may be reasonably sure that under these circumstances every opportunity for the display of his abilities was afforded a favorite pupil.

Ecclesiastical Career.

The attention he attracted at Basel led to his selection as the Papal representative at the Diets of Mainz in 1441, of Frankfurt in 1442, of Nuremberg in 1444, and of a second Diet at Frankfurt in 1446, so that probably no ecclesiastic in Europe was better known to the hierarchy of his native country than Nicholas. Successive Popes came to have the highest confidence in him, and he was sent as legate to many places not only in Germany but also in France and Switzerland and other countries. He refused the Cardinalate when it was first offered to him, and it required a special order of Pope Nicholas V to make him assume this honor later. He was made Bishop of Brixen because that diocese was considered to need a firm hand and yet a diplomatic heart and a sympathetic humanity to bring about the obliteration of abuses that had been allowed to creep into the diocesan institutions. It is not too much to say that probably no one was so close to the Popes or so thoroughly incarnated the policy of the Church of his time as Cardinal Nicholas of Cusa, and yet after Roger Bacon himself there is almost no one in whose works are found so many anticipations of modern science as in those of Cusanus.

It might well have been expected that his rise in the hierarchy would have made him cautious, and that he would have felt that his ecclesiastical duties made it advisable for him to avoid scien-

tific speculations. So far from this being the fact, however, it was mainly while he was in the midst of his busy life as a high ecclesiastic that his scientific works were written. There was not only no hesitancy on his part as to the advisability of his continuing his writing on extraneous scientific subjects, but quite as evidently there was no feeling on the part of his colleagues in the hierarchy that it would be better for him to confine himself to religious subjects.

In recent years our growing knowledge of the Middle Ages has led a number of people to recognize that in the despised Middle Ages there was a liberality toward philosophic thought, especially in the great university centers, which afterward came to be narrowed. Indeed it has been often suggested that the shackles of ecclesiastical authority were put on tighter over the human mind during the fourteenth and fifteenth centuries than they had been earlier. For some it constitutes the reason why the Reformation, with its definite break for liberty, had come. Of any such ideas as these, however, the life of Cardinal Nicholas of Cusa is an open contradiction. Nothing that I know shows so well how perfectly free the churchman might be to follow out speculations of all kinds, not only without danger to his personal liberty, but even without detriment to his ecclesiastical career in any way, and indeed his broad liberality of mind seems to have been one of the reasons that aided rather than hampered his successful career.

Independence of Thought.

There is abundant evidence in Nicholas of Cusa's writings of his thoroughgoing independence of thought and his power to think for himself. Writing about him in an essay in *Old Time Makers of Medicine*, so as to explain to physicians how it was that he was the first to make a suggestion of laboratory methods in diagnosis, I said of him: "There are many interesting expressions in Cusanus's writings which contradict most of the impressions commonly entertained with regard to the scholars of the Middle Ages. It is usually assumed that they did not think seriously, but speculatively; that they feared to think for themselves, neglected the study of nature around them, considered authority the important source of knowledge, and were as far as possible from the standpoint of modern scientific students and investigators. Here is a passage from Nicholas, on writing and thinking, that might well have been written by a great intellectual man at any time in the world's history, and that could only emanate from a profound scholar at any time." It runs:

> To know and to think, to see the truth with the eye of the mind, is always a joy. The older a man grows, the greater is the pleasure which it affords him; and the more he devotes himself to the search after truth, the stronger grows his desire of possessing it. As love is the life of the heart, so is the endeavor after knowledge and truth the life of the mind. In the midst of the movements of time, of the daily work of life, of

its perplexities and contradictions, we should lift our gaze fearlessly to the clear vault of heaven, and seek ever to obtain a firmer grasp of and a keener insight into the origin of all goodness and beauty, the capacities of our own hearts and minds, the intellectual fruits of mankind throughout the centuries, and the wondrous works of nature around us; at the same time remembering always that in humility alone lies true greatness, and that knowledge and wisdom are alone profitable in so far as our lives are governed by them.

What Nicholas succeeded in thinking out for himself in astronomy is probably the most striking testimony to his individuality of intellect and power to see things for himself. Father Hagan, who is the Papal Astronomer in charge of the Observatory in the Vatican, has summed it up in a paragraph of his sketch of Cardinal Nicholas in the *Catholic Encyclopedia*.

The astronomical views of the Cardinal are scattered through his philosophical treatises. They evince complete independence of traditional doctrines, though they are based on symbolism of numbers, on combinations of letters, and on abstract speculations rather than observation. The earth is a star like other stars, is not the centre of the universe, is not at rest, nor are its poles fixed. The celestial bodies are not strictly spherical, nor are their orbits circular. The difference between theory and appearance is explained by relative motion. Had Copernicus been aware of these assertions, he would probably have been encouraged by them to publish his own monumental work.

Like Roger Bacon, Nicholas of Cusa recognized very clearly how much that was accepted

in his generation, often even by men supposed to be learned, was not true. His best known book is called *De Docta Ignorantia*, that is, "About Learned Ignorance". I wonder if there ever was a time in the world's history when one could not write about learned ignorance. Even the educated people of any period are always ready to accept a large number of theories that prove after a while to have been utterly mistaken. Often the wiser men of their generation see very clearly, though there is no hope of their convincing their fellows, how utterly insignificant, especially to any such extent as their contemporaries believe them, are the current theories of the day. We are still intent on passing theories, fairly slaves to them, while they last, and then dropping them for others. The therapeutics of any generation has always been absurd to the second succeeding generation, but so have the current theories in any department of science. Up-to-date thinking is in a few years scarcely recognizable in the lumber room of cast-off hypotheses.

One of our greatest American humorists has said in our time: "It is not so much the ignorance of mankind that makes them ridiculous, as the knowing so many things that ain't so." We are just getting to recognize that what in our ignorance — to quote John Fiske, surely an authority not likely to be suspected of partiality to the Middle Ages — we used to call the Dark Ages ought to be called the Bright Ages. When

we had no architecture, no beautiful buildings inside and outside, no arts and crafts worth while speaking of, we could not understand the Middle Ages and so forsooth called them "dark". Now when we are imitating their architecture, taking the models of their wrought iron and carved stone and woodwork for our developing arts and crafts, when we are going back to study their great poets, Dante, the Cid, the Troubadours, the Meistersingers and the Minnesingers, we are beginning to realize what a wonderful time it was. There is a fine opportunity in our time for another book with the title "On Learned Ignorance". The surprise is—but only for those who do not know their Middle Ages—to find that the first book bearing that title was written before the close of the Middle Ages.

It is stated in his book *De Docta Ignorantia* that the Great Cardinal set forth a theory with regard to the constitution of the sun. How clearly he anticipated some modern views, which it would seem almost impossible for a medieval scholar and above all a churchman to have had any hint of, may be seen particularly in this solar theory. It is all the more surprising that he should, by some form of intuition as it were, reach the conclusions he did, for the usual sources of information with regard to the sun in his time could not possibly have brought him to such a theory, and it was only his own genius far outrunning the knowledge of his time that enabled him to do it. The Cardinal said:

To a spectator on the surface of the sun the splendor which appears to us would be invisible, since it contains, as it were, an earth for its central mass, with a circumferential envelope of light and heat, and between the two an atmosphere of water and clouds and of ambient air.

After reading that bit of precious astronomical science announced nearly five centuries ago, it is easy to understand how Cusanus anticipated other phases of our knowledge, as he did in his declarations that the figure of the earth is not a sphere, but is somewhat irregular, and that the orbit of the earth is not circular.

Perhaps in our time it will be most interesting to find that in the field of politics, too, Nicholas of Cusa was capable not only of original thinking, but in this as in so many other fields of thought he anticipated some of the greatest conclusions of the modern time. As the result of his careful studies of conditions in Germany, he realized very clearly how much of unfortunate influence the political status at that time of the German people, with their many petty rulers and the hampering of development consequent upon the trivial rivalries, the constant bickerings, and the inordinate jealousies of these numerous princelings, had upon his native country. Accordingly, toward the end of his life he sketched what he considered would be the ideal political status for the German people. As in everything that he wrote, he went straight to the heart of the matter and, without mincing words, stated

just exactly what he thought ought to be done. Recalling that this scheme of Cusanus for the prosperity and right government of the German people was not accomplished until more than four centuries after his death, it is interesting, indeed, to realize how this clergyman of the middle of the fifteenth century should have come to any such thought. Nothing, however, makes it clearer than this, that it is not the progress of time that fosters thinking, but that great men at any time come to great thoughts. Cusanus wrote:

> The law and the kingdom should be placed under the protection of a single ruler of authority. The small separate governments of princes and counts consume a disproportionately large amount of revenue without furnishing any real security. For this reason we must have a single government, and for its support we must have a definite amount of the income from taxes and revenues yearly set aside by a representative parliament, and before this parliament (reichstag) must be given every year a definite account of the money that was spent during the preceding year.

A Pioneer in Accurate Medical Science

Our modern advance in medicine, in so far as it is real and enduring and not merely sensational and apparent, is dependent more on the development of accurate methods of diagnosis than any other single factor. Very few people realize that, in spite of all that has been said with regard to supposed advances in the treatment of disease, the dozen drugs that doctors use most and

which they consider absolutely indispensable in the treatment of their patients, are all more than a century old, and some of them many hundreds of years, and a few of them some thousands of years old. It is in diagnosis that significant scientific advances have been made. The more we have been able to use mechanical means of various kinds and scientific instruments and mathematical formulae, the more valuable has been the accumulation of data with regard to diseases and the differentiation of disease conditions so as best to assure their rational treatment.

Now I suppose that the last place in the world that one might expect to find the first hint toward the employment of accurate methods of diagnosis in modern times would be before the end of the Middle Ages. Very probably the last person who would be expected to give such a hint would be a medieval churchman trained by the knowledge of the classics in early life, with his degree in canon law, not in medicine. If to this be added the fact that the author was a Cardinal of the Church, valued by his ecclesiastical contemporaries for his knowledge of theology, it cannot but seem almost impossible that it should be in his works that is to be found one of the earliest valuable suggestions for the application of a thoroughly scientific method to medicine.

In spite of this apparent impossibility, it is, as I have shown in my *Old Time Makers of Medicine*, to Cardinal Nicholas of Cusa that we owe the first hint of accurate diagnostic methods in

clinical medicine, and his work has now become a well-recognized chapter in the history of medicine. In an article on "An Early Allusion to Accurate Methods in Diagnosis" which was published in the *Archives of Diagnosis*,[1] I reviewed the place of Cardinal Nicholas's suggestion in our history of clinical medicine and pointed out its definite significance. That story is worth while repeating here because it is such a surprising revelation of the way that genius, when apparently wandering far afield from its own special interest and intruding on others' work, is able to give hints that may prove extremely valuable, though for the moment they may be so far ahead of current scientific thought as to be unavailable.

Some years ago Professor Ernst von Leyden, at that time the Director of the First Medical Clinic of the Charité Hospital, Berlin, and one of the best known of the teachers of medicine at the University of Berlin, in sketching the history of the taking of the pulse as an important aid to diagnostics in medicine, said that John Floyer, an English clinician, is usually named as the man who about the beginning of the eighteenth century introduced the practice of determining the pulse rate by means of the watch. He suggested, however, that William Harvey, the English physiologist to whom we owe the discovery of the circulation of the blood,

[1] New York, April, 1909.

had before Floyer suggested the use of the watch in counting the pulse and the value of the pulse in medical diagnosis.

Professor Carl Binz of the University of Bonn, commenting on these remarks of von Leyden, called attention to the fact that two centuries before either of these men, to whom the careful measurement of the pulse rate is attributed as a discovery, were born, a distinguished German churchman, who died shortly after the middle of the fifteenth century, had suggested a method of accurate estimation of the pulse that deserves a place in medical history. This suggestion is so much in accord with modern demands for greater accuracy in diagnosis that it seems not inappropriate to talk of it as the first definite attempt at laboratory methods in the department of medicine. The pioneer of this important subject of accurate diagnosis was Cardinal Nicholas of Cusa. The Cardinal suggested that in various forms of disease and at various times of life, as in childhood, boyhood, manhood, and old age, the pulse was very different. It would be extremely valuable to have some method, then, of accurately estimating, measuring, and recording these differences for medical purposes. At that time watches had not yet been invented, and it would have been very difficult to have estimated the time by the clocks, for almost the only clocks in existence were those in the towers of the cathedrals and of the public buildings. The first watches, " Nuremberg eggs ", as they

were called, were not made by Peter Henlein until well on in the next century. The only method of measuring time with any accuracy in private houses was the clepsydra or water-clock, and Cardinal Nicholas suggested that this should be employed for estimating the pulse frequency. His idea was that the amount of water which flowed while a hundred beats of the pulse occurred should be weighed and this weight compared with that of the water which flowed while a hundred beats of the normal pulse of a number of average individuals of the same age were being counted.

Cusanus was an extremely practical man, he was constantly looking for and devising methods of applying practically principles of science to ordinary life. As we shall see in discussing his plan for the estimation of the pulse rate later on, he made many other suggestions for diagnostic purposes in medicine and suggested other applications of mathematics and mechanics to his generation.

The book in which the suggestion as to the accurate estimation of the pulse rate was made is of special interest to physicians. It is his Dialogue *On Static Experiments*, which he wrote in 1450 and which contains the following passages:

> Since the weight of the blood and the urine of a healthy and of a diseased man, of a young man and an old man, of a German and an African, is different for each individual, why would it not be a great benefit to the physician to have all these various differences

classified? For I think that a physician would make a truer judgment from the weight of the urine viewed in connection with its color than he could make from its color alone, which might be fallacious. So also weight might be used as a means of identifying the roots, the stems, the leaves, the fruits, the seeds, and the juice of plants, if the various weights of all the plants were properly noted together with their variety according to locality. In this way the physician would appreciate their nature better by means of their weight than if he judged them by their taste alone. He might know then from a comparison of the weights of the plants and their various parts when compared with the weight of the blood and the urine, how to make an application and a dosage of drugs from the concordances and differences of the medicaments and even might be able to make an excellent prognosis in the same way. Thus, from static experiments he would approach by a more precise knowledge to every kind of information.

Do you not think, if you would permit the water from the narrow opening of a clepsydra (water-clock) to flow into a basin for as long as was necessary to count the pulse a hundred times in a healthy young man, and then do the same thing for an ailing young man, that there would be a noticeable difference between the weights of the water that would flow during the period? From the weight of the water, therefore, one would arrive at a better knowledge of the differences in the pulse of the young and the old, the healthy and the unhealthy, and so also as to information with regard to various diseases, since there would be one weight and therefore one pulse in one disease, and another weight and another pulse in another disease. In this way a better judgment of the differences in the pulse could be obtained than from the touch of the vein, just as more can be known from the urine about its weight than from its color alone.

Just in the same way would it not be possible to make a more accurate judgment with regard to the breathing if the inspirations and expirations were studied according to the weight of the water that passed during a certain interval? If while water was flowing from a clepsydra, one were to count a hundred expirations in a boy, and then in an old man, of course there would not be the same amount of water at the end of the enumeration. Then this same thing might be done for other ages and states of the body. As a consequence, when the physician once knew the weight of water that represented the number of expirations of a healthy boy or youth and then of an individual of the same age ill of some infirmity or other, there is no doubt that by this observation he will come to a knowledge of the health or illness and something about the case, and perhaps also with more certainty would be able to choose the remedy and the dose required. If he found in a healthy young man apparently the same weight as in an old and decrepit individual, he might readily be brought to the conclusion that the young man would surely die and in this way have some evidence for his prognosis in the case. Besides, if in fevers in the same way careful studies were made of the differences in the weight of water for pulse and respiration in the warm and the cold paroxysms, would it not be possible thus to know the disease better and perhaps also get a more efficacious remedy?

As will be seen from this passage, Cusanus had many more ideas than merely the accurate estimation of the pulse frequency when he suggested the use of the water-clock. Evidently the thought had come to him that the specific gravity of the substances, that is, their weight in comparison to the weight of water, might be valuable

information. Before his time physicians had depended only on the color and the taste of the urine for diagnostic purposes. He proposed that they should weigh it, and even suggested that they should weigh also the blood, I suppose in case of venesection for comparison's sake. He also thought that the comparative weight of various roots, stems, leaves, juices of plants might give hints for the therapeutic uses of these substances. This is the sort of idea that we are apt to think of as typically modern. Specific gravities and atomic weights have been more than once supposed to represent laws in therapeutics that so far we have not succeeded in finding, but it is interesting to realize that it is nearly five hundred years since the first thought in this line was clearly expressed by a distinguished thinker and scientific writer.

Charity and Loyalty.

On the death of his father considerable property reverted to Cardinal Nicholas of Cusa, and by mutual agreement with his sister Clare and his brother John his entire inheritance was converted to a foundation for the benefit of the poor. During the five years from 1451 to 1456 extensive buildings were erected in his native town with chapel, cloister, and refectory attached. These were to serve as home for thirty-three old men in honor of the thirty-three years of Christ's earthly life. This institution is still standing and would remind one of the Grey

Friars in which in Thackeray's *The Newcomes*, Colonel Newcome takes his refuge at the end of his life. Cardinal Nicholas by his last will left his altar service, his manuscript library, and his scientific instruments, to this hospital, as it was called, for at that time the word hospital meant only a guest house and had not become restricted in significance to a place where only ailing folk were given shelter. These bequests would seem to indicate that the institution founded by Cardinal Nicholas was meant to be something more than a refuge for the old, and that he intended it to provide instruction also for the young. This was a feature of the English Grey Friars, for the famous "blue coat boys" went to school there; and it is typical of the spirit of the Middle Ages thus to bring together youth and age for the sake of the mutual beneficent influence that they exercise on each other.

Even more significant for our appreciation of the Cardinal's interests in life is the fact that, though his body rests in his own titular church in Rome beneath the sculptured effigy of him in relief provided by the Renaissance spirit, he arranged that his heart should be deposited before the altar in the hospital of Cues. He wanted his heart to be where his treasure was, and in life he had often exhibited the feeling that the real treasure of the Church is the poor.

He did not forget his Alma Mater at Deventer when he became a Cardinal, for he founded there a residence called after him the *Bursa Cusana*.

where twenty poor students were to be supported. In a word, this scholarly scientist and distinguished ecclesiastical diplomat, who might be expected to be immersed in important ecclesiastical matters to the exclusion of interest in the needs of his native town and his first school, turned to accomplish concrete good by solving the social problems that he had been brought intimately in contact with during his early years. Best of all, he did not wait till after his death to make the foundations, but arranged for them during his life and saw to their organization according to his plans for them.

It is, above all, significant that a man of these broad intellectual interests and profound ability should have been selected by successive Popes as the person to whom the reforms of various abuses in German dioceses should be committed. The reform of abuses in any institution composed of human beings will always have to be made. They had crept in in many places in Germany and needed correction. To Nicholas of Cusa their reformation was committed, and while he made many enemies, almost necessarily, while engaged in such work, the friends he made far outnumbered these. Indeed the Abbot Trithemius, himself one of the most distinguished scholars and churchmen of that time, did not hesitate to say that everywhere Nicholas had appeared as an angel of light and of peace. So much of what we have heard of pre-Reformation history, especially as regards Germany, is so

very different from this that it is worth while noting both the character of the man and his work, whom Rome selected for the delicate mission of reformation. Certainly, as we look back at it now, no wiser selection than this, looked at from every standpoint, could, humanly speaking, have been made. Cusanus's career is in itself an epitome of the times, full of the most significant historical meaning.

IV.

ABBÉ SPALLANZANI: A CLERICAL PRECURSOR OF PASTEUR.

WHO loves not knowledge? Who shall rail
Against her beauty? May she mix
With men and prosper! Who shall fix
Her pillars? Let her work prevail.
—TENNYSON, *In Memoriam*, CXIV.

WHILST mind unfettered o'er the earth extends
Its all-subduing energies, and wields
The sceptre of a vast dominion there.
—SHELLEY, *The Demon of the World*.

IV.

ABBÉ SPALLANZANI: A CLERICAL PRECURSOR OF PASTEUR.

UNDOUBTEDLY one of the most interesting problems of biology, and one that has deservedly attracted a great deal of attention in recent years—indeed it is now declared to be a key factor as regards certain phases of the theory of evolution—is what is known as regeneration. All of us know from experience that we have certain powers of regeneration, so that injuries, cuts, and even rather serious wounds are repaired by regenerative processes, which in a great many cases restore almost, if not quite completely, the original appearance of the skin surface. Imagine what battered bodies most human beings would present if every injury that went through the skin made a permanent scar or even left some definite trace. Not only it does not, but even rather deep injuries, if not followed by suppuration, are repaired so well that absolutely all trace of them may be lost, or at least only very slight marks of them left. This is due to the power of regeneration in the living being.

Some of the lower animals possess this power of regeneration to a marvelous degree. For instance, there are certain salamanders or lizards that regenerate whole limbs when they are lost.

When we recall that the limb of an animal contains bones, muscles, nerves, arteries, tendons, as well as various layers of connective tissue, usually spoken of as *fasciæ* because they bind certain tissues together in a way to facilitate their activity, it is easy to understand what a complex problem is here presented. How is this restoration accomplished? When the limb of the salamander is removed, all that is left is the jagged remnant of a limb with a superficial series of more or less injured cells, practically all of which will disappear before the true process of repair begins. The next row of cells behind these, the first healthy cellular layer, proceeds to grow, and then the cells lay themselves down in regular order until they have recreated the limb as it was originally.

Perhaps the fulness of the mystery that is thus briefly outlined will be better appreciated from an illustration. Suppose that a cyclone should blow off a wing of a brick building, as storms have sometimes been known to do, leaving the main portion standing. A jagged edge of bricks—many of them broken, some of them displaced, not a few of them torn from their original location, yet still hanging on — would represent the outer surface of what was left. All these injured and dislocated bricks have to be removed before men can begin the repair. Suppose now the first row of uninjured bricks that were still in place after having pushed the displaced broken bricks out of the way, should

begin to double, and then double again, and so on, laying themselves down in order on top of each other, until there would be a complete wing where the former one was. That is a picture on a large scale of what happens on a small scale when an animal's limb is torn away and then regenerated by a process of nature.

It must not be forgotten, however, that in order to restore the wing of the building not only must the bricks be laid in regular order, but there are floors and partitions and stairs and corridors and doors and windows and wainscotings and plaster, and all the other contents of the building, to be put in place. These must be built up by degrees; but the work is no more complex than the making of bone, muscle, sinew, tendon, joints, joint capsules, arteries, veins, nerves — these three latter corresponding to the plumbing, the water supply, the drainage, and the electric bells or the telephones in the buildings.

How is so wonderful a work accomplished? Of course it is no more wonderful than the original growth of the limbs; but, then, somehow we do not think so much of that. Where is the memory which recalls all the details of the limb that was lost, and where is the force that directs all the energies that accomplish the work? We call in an architect to plan the building, and then employ a contractor to direct the workmen how to do it—the architect controlling the contractor's work. But where is all this mechanism in

the little lizard, which, having lost a limb, proceeds to develop a new one just exactly like its predecessor?

It is easy to understand what an interesting biological problem is here involved. Now, the first man to study this problem from the serious scientific standpoint was Lazaro Spallanzani, a clergyman of the eighteenth century. But even the fact that he was a clergyman is not so surprising, perhaps, as the further information with regard to him—that his taste for scientific studies was aroused by a distinguished woman professor of the University of Bologna, Laura Bassi, who was a cousin of his. And, then, there is another surprise awaiting this generation — that a great deal of his work was facilitated by his sister Marianna, who became interested in the natural sciences (or, as they were then called in general terms, natural philosophy), in order to be of help to her brother. She is one of the many "Little Known Sisters of Well Known Men", as runs the title of a recent American book—which does not, however, contain her name: nor, for that matter, the name of Caroline Herschel, who a little later was to be of so much assistance in his work to her brother, the famous Herschel the astronomer. We forget sometimes that sisters have often been deeply affectionate toward brothers of scientific genius, and that some of them, even long before our generation, have had the intelligence to reinforce their affec-

tion and accomplish excellent results as their auxiliaries.[1]

It is because of the many contradictions of ordinary impressions as regards the history of science that the life of Lazaro Spallanzani seems to deserve recall for our generation, because it is a keynote of actualities in history that are not well understood. For indeed the Abbé Spallanzani, as he is usually called, was famous. He was offered chairs in literally more than half a dozen universities before he reached middle life; and later on he was made a member of academies and learned societies in many of the cities of Europe—not alone in his native Italy, but in

[1] Marianna Spallanzani's distinguished services to her famous brother are all the more interesting because such feminine developments in Italy are usually not thought (at least in English-speaking countries in our time) ever to have been possible. Even Dr. Mozans, in his book, *Women in Science,* always so thorough, and usually so exhaustive, has missed Marianna Spallanzani's story. The arrangement of the cabinet of Natural History which came to be the focus of the scientific attention of Europe at Pavia was largely in her hands. Spallanzani often confessed that she knew more about it than he did. During his absence, distinguished visitors were taken through the cabinet by Marianna; and, as one of Spallanzani's biographers (Senebier) says naïvely enough, "she knew the properties of all the specimens contained in it, and was capable of reasoning upon them." He adds, moreover, the secret of her successful cultivation of natural science; for "her mind was molded upon that very illustrious brother, whom it was pleasure to her to study and imitate."

Berlin, London, Paris, Madrid, and in distant Stockholm, Upsala, and other places. He was one of the most distinguished scientists of the eighteenth century, known throughout all Europe, and particularly well known because of his controversies on spontaneous generation. Spallanzani had the modern idea in the matter, and insisted that there was no such thing as spontaneous generation, but that life was always the result of preceding life. Though his dictum in the matter was disputed by Needham and Buffon, he came off victorious in controversies with them. He had similar good fortune also in a controversy with John Hunter on a topic relating to digestion, though at the time Hunter was rightly looked up to as one of the most distinguished authorities in Europe on questions of anatomy and physiology.

What is even more to Spallanzani's credit, however, than his success in the controversies in question is the fact that, notwithstanding that the temper of controversy in the eighteenth century was, almost as a rule, very bitter (though not so bitter as it had been in the seventeenth), and readily became personal, Spallanzani never stooped to anything of that kind. He was noted for the gentleness of his ways and the suavity of his manners. He probably did more than any one else of the period to set the example, general in our time, according to which scientists or grammarians or mathematicians may disagree without acrimony.

When, at the beginning of the twentieth century, Dr. Thomas Hunt Morgan, Professor of Biology at Bryn Mawr College, gave the series of lectures on regeneration at Columbia University, which were published in the Columbia University Biological Series,[2] he reviewed in his introductory lecture Spallanzani's work, regretting that, unfortunately, the complete account of the Italian clergyman's experiments had never been published. As Professor Morgan has since come to be looked upon as the authority on regeneration not only in this country but in the scientific world generally, his epitomization of Spallanzani's work is thoroughly authoritative. Here, for instance, is a brief résumé of the Spallanzani observations on earthworms:

> He made a large number of experiments with earthworms of several kinds, and found that a worm cut in two pieces may produce two new worms, or, at least, that the anterior piece produces a new tail, which increases in length, and may ultimately represent the posterior part of the body. The posterior piece, however, produces only a short head at its anterior end, but never makes good the rest of the part that was lost. A short piece of the anterior end fails to regenerate; but in one species of earthworm, that differs from all the others in this respect, a short anterior piece or head can make a new tail at its posterior end. Spallanzani found also that if much of the anterior end is cut off, the development of a new head by the posterior piece is delayed, and, in some species, does not take place at all. If a new head is cut off, another

[2] Macmillan Co., 1901.

is regenerated; and this occurred in one case five times. If, after a new head has developed, a portion is only cut off, the part removed is replaced; and if a portion of this new part is cut off, it is also regenerated. If a worm is split longitudinally into two pieces, the pieces die. If only a part of the worm is split longitudinally and one part removed, the latter will be regenerated from the remaining part.

Spallanzani's experiments on other crawling creatures, especially the tadpole and the salamander, were not less interesting or less significant; and these two have been epitomized by Professor Morgan in such a way as to make it clear that Spallanzani's observations were carefully made, and that practically no phase of the problems was neglected. Any one who thinks that biologic experimentation is in any sense modern or recent, or that the older scientists depended too much on theory and did not ask direct questions of nature, or diversify the terms of their experiment in such a way as to search out the definite significance of the phenomena in which they were interested, needs only to read this epitomization of Spallanzani's work on regeneration to have all such false notions obliterated. Professor Morgan says:

Spallanzani found that a tadpole can regenerate its tail; and if a part of the new tail is cut off, the remaining part will regenerate as much as is lost. Older tadpoles regenerate more slowly than younger ones. If a tadpole is not fed, it ceases to grow larger, but it will still regenerate its tail if the tail is cut off. Salamanders also regenerate a new tail, producing even

new vertebræ. If a leg is cut off, it is regenerated; if all four legs are cut off, either at the same time or in succession they are renewed. If the leg is cut off near the body, an imperfectly regenerated part is formed. Regeneration of the legs was found to take place in all species of salamanders that were known to Spallanzani, but best in young stages. In full-grown salamanders regeneration takes place more promptly in smaller species than in larger ones. Curiously enough, it was found that if the fingers or toes are cut off, they regenerate very slowly. If the fingers of one side and the whole leg of the opposite side are cut off at the same time, the leg may be regenerated as soon as the fingers of the other side. A year is, however, often insufficient in some forms for a leg to become fully formed. If an animal is kept without food for two months after a leg has been cut off, the new leg will regenerate as rapidly as in another salamander that has been kept fed during this time. If the animal is kept longer without food, it will decrease in size, but nevertheless the new leg continues to grow larger. Occasionally more toes or fewer toes than the normal number are regenerated; but as a rule the fore leg renews its four toes, and the hind leg its five toes.

In one experiment, all four legs and the tail were cut off six times during the three summer months, and were regenerated. Spallanzani calculated that (in this process in a single animal) 647 new bones must have been made in the new parts. The regeneration of the new limbs was as quickly carried out the last time as the first. Spallanzani also found that the upper and lower jaws of salamanders can regenerate.

Professor Morgan has also touched upon Spallanzani's experiments on the snail and slug. If the tentacles are removed, they are renewed; and, to quote Professor Morgan, "Spallanzani

found that even if the entire head is cut off a new one is regenerated. Also other parts of the snail, as the foot and the collar, may be regenerated. The head of the slug, it was found, regenerates with more difficulty than that of the snail." No wonder that Professor Morgan did not hesitate to say that the justly celebrated experiments of Spallanzani and his contemporaries furnish the basis of all later work, and that many of the important facts in regard to regeneration were made known by their investigations.

Abbé Spallanzani's experiments on regeneration, then, as can readily be understood, were not merely superficial investigations of a curious phenomenon, but very definite and searching questions put to nature with regard to this important function of tissues. Spallanzani actually showed that not only the tails and limbs of many creatures, like tadpoles, salamanders, and snails, could be regenerated on removal, but that some of these creatures could regenerate their heads; though it was afterward found that, in these cases, what had been called the head of the animal did not contain the essential part of the central nervous system. In the course of these experiments, he brought out very clearly how important was the spinal cord as a portion of the central nervous system. Up to this time the spinal cord has been considered as merely a sort of bundle of nerves running together through the canal in the spinal vertebræ, somewhat as the elements of an electrical cable run through

a tube or tunnel. Spallanzani's experiments show, however, that the spinal cord contains a number of important reflex centers, which bring about reflex movements and functions of various kinds quite independently of the brain, and almost entirely without reference to it.

His experimental removal of the head of the land snail, followed by its regeneration, was doubted until a series of observers had controlled and confirmed his conclusions. It was afterward shown that this does not contain the brain; but it does contain the eyes, the mouth, the tongue, the teeth, and most of the sense organs of the animal, and these are all regenerated. In a word, the whole subject of regeneration was gone into so thoroughly as to make it a special chapter in biological science. In the midst of preoccupations with other developments, and particularly the cell doctrine, this subject was neglected in the nineteenth century, until, during the last two decades of that period, Roux, Driesch, and others in Germany, as well as Thomas Hunt Morgan, Loeb, and other American biological investigators, took it up again and showed its significance. Practically, all that they have accomplished has added little to our knowledge of the details of it, though they have succeeded in pointing out how much the possession of the faculty of regeneration tells against Darwinism.

While Spallanzani's studies in regeneration have attracted attention to him, particularly in our time, it was his work on so-called spontan-

eous generation that gave him his reputation in the eighteenth century. The question of the possibility of the spontaneous origin of life (abiogenesis, as it is called scientifically—that is, of the occurrence of life as the result of non-living forces and without any necessary relation to preceding life) has often occupied men's minds, and, above all, in the nineteenth century was the subject of not a little thought and a great deal of experimentation. Even distinguished scientists have lent themselves to the conclusion that life could thus originate of itself, as, for instance, in the moist, hot climate of a tropical country, or in the slime at the bottom of the ocean. Huxley rather brought himself into ridicule by his acceptance of bathybius — a low order of life, as its Greek name implies, which was supposed to be intermediate between non-living or non-organic material and living or organic material. In some minds the problem is not yet settled; for all those who refuse to accept creation as the origin of life, consider that life must have come into existence originally by some chance disposition of merely physical factors.

In centuries preceding the nineteenth, all sorts of curious notions with regard to the spontaneous origin of life were accepted even by scientific minds. The old Greeks were quite sure that insects and even other highly organized forms of life sprang into existence as the result of merely favorable physical conditions. Putrefy-

ing material, for instance, was supposed actually to generate little living things. The Romans adopted this set of ideas from the Greeks; and everyone will recall Virgil's very curious description of the way to obtain a swarm of bees, by allowing a carcass to rot on a hillside in the sun. He had evidently mistaken the buzzing flies, so often with curiously brilliant wings and bodies, which are seen under such circumstances, for young bees; though perhaps he had never seen the phenomenon, but merely adopted it, as he did most of the biological and agricultural hints in his Georgics from writers of curious things in the world around him.

One of the well-known names at the beginning of modern science was Van Helmont, to whom we owe the word "gas", and who is looked upon as one of the most distinguished medical scientists of the seventeenth century. His ideas, therefore, would be reasonably representative of the science of his time. He was indeed the founder of the iatrochemical school in medicine, which did so much to suggest the chemistry of the human body as the basis of pathology and the scientific foundation for therapeutics. We owe to him the physiological importance of ferments and gases, particularly of carbonic acid; and his knowledge of the bile, the gastric juice, and the acids of the stomach was considerable.[3]

[3] Garrison, *History of Medicine.*

In spite of all this knowledge of chemistry in general and the chemism of the body in particular, in which he was practical enough to introduce the gravimetric idea in the analysis of urine, which has since been of so much importance, Van Helmont had what would seem to us the most absurd notions with regard to the subject of the origin of even highly organized life, and of spontaneous generation in general. He suggested, for instance, that even living beings so high in the scale of life as mice might be obtained by spontaneous generation. The terms of the experiment were that some meal should be taken, placed in an earthenware jar in a dark corner of a cellar, covered with dirty linen (this latter seemed to be an important factor in the experiment); and he said that in the course of a few weeks mice would be found making a home in the meal. This occurrence of life he considered to be due to spontaneous generation; and, as he had tried the experiment a number of times, he was quite convinced that his conclusion in the matter was scientific.

In the eighteenth century they had gone far beyond these crude notions at least, though many scientists were still inclined to think that insects were produced spontaneously in decaying or rapidly changing organic matter; and that surely the smaller living things (the animalcules, as they called them — the micro-organisms or microbes, to use the familiar name of the modern time) arose spontaneously.

Curiously enough, about the middle of the eighteenth century, the controversy over spontaneous generation was between two Catholic clergymen — one of them Father Walter Needham, an Irish priest whom the Penal Laws made an exile on the Continent, and who devoted a good deal of his leisure time to biological experiments; the other, our Abbé Spallanzani. In 1748 Father Needham published the account of certain experiments on boiled meat juices, which were enclosed in glass phials and sealed, so that apparently whatever developed in them must come from their contents and not in any way from without. As the boiling was presumed to have killed all life in the organic materials, the subsequent presence of micro-organisms in these liquids seemed to demonstrate that these must have been produced by spontaneous generation. The same controversy, almost in the same form, was destined to come up in the nineteenth century, when Pasteur's crucial experiments once more refuted the idea of spontaneous generation.

Spallanzani anticipated Pasteur by repeating Father Needham's experiments under conditions which showed conclusively that whenever, after thorough boiling, the air was completely excluded from the flasks, no life ever developed in them. He used glass flasks which could be hermetically sealed in flame, immersing them in boiling water prior to the test. When Father Needham objected that the real reason for the failure of subsequent occurrence of micro-organisms in the

organic fluids was that their exposure to the flame had killed the "vegetative force" in them which would have enabled them to support life, Spallanzani extended this experiment so as to show that just as soon as the sealed fluids were exposed to the air once more, they were thoroughly capable of supporting organic life, only *that* life must be introduced into them from without. This work, almost needless to say, attracted a great deal of attention; and Spallanzani's triumphant demonstration of his ideas gave him great scientific prestige throughout Europe, and created as well a new point of view which was to form a firm fundamental principle in modern science.

Regeneration and spontaneous generation were only two out of many subjects that Spallanzani treated in the field of what we now call biology. There were many others. Digestion, generation, fertilization, respiration, circulation, were all taken up, and all of them illuminated by his genius; for there is no other word for his marvelous power of observation, his infinite patience in diversifying his experiments, his ingenuity of device for his questions to nature, and his pertinacity in following up hints to definite conclusions.

Probably the most interesting discovery made by Spallanzani was that of the digestive power of the saliva. Ordinarily it was assumed up to that time (and the idea is still prevalent enough) that the purpose of saliva was mainly to moisten

ST. ALBERT'S COLLEGE LIBRARY

the food and make it easier to swallow; and, as a matter of fact, this is one of its important functions. So far from this being the all-important function, however, it is now well understood that, if saliva does not become mixed properly with starchy food, its digestion is not a little interfered with, or at least hampered. If the starches are always presented in such form that very little chewing is needed — as, for instance, when potatoes are mashed, and peas and beans are puréed, and only the soft portions of bread eaten, or bread always soaked in some fluid before being eaten — the digestion of the starch is rendered difficult. On the other hand, if a piece of bread be chewed faithfully, and especially a crust of bread chewed until it is ready to swallow without any fluid being taken, the substance becomes sweet in the mouth, showing that the saliva is already bringing about a change of the starch of the bread into sugar. Something of this change ought always to take place in the mastication of starchy foods.

We owe the knowledge of this important function of the saliva to Spallanzani, who also extended the knowledge of the gastric juice as a solvent of food in the stomach. This fact had been known before, and the function of the gastric juice had been scientifically determined; but Abbé Spallanzani showed that the gastric juice acts outside the body, and somehow contains in itself apart from the stomach, once it has been secreted, the digestive power. This led later to

the preparation of pepsin from animals' stomachs as an adjuvant to human digestion. Spallanzani also showed that the gastric juice prevented the putrefaction of even the most highly organized materials, and that it had the power of stopping putrefaction even after it had once begun. As a matter of fact, his thoroughness of investigation of the subject set stomach digestion on a scientific plane that was little raised until well on toward the end of the nineteenth century.

Regeneration and digestion are two very important subjects to have illuminated so well as Spallanzani illuminated them; but after this he took up the subject of respiration, and left it as much his debtor as that of digestion. He studied not only the respiration of warm but also of cold-blooded animals. By experiments, he demonstrated that animals that hibernate—that is, pass the winter in a sort of comatose condition—consume only an almost infinitesimal amount of oxygen. Indeed, he demonstrated that they can live comfortably for a considerable time in an atmosphere of carbon dioxide, in which ordinary warm-blooded animals will perish in the course of a few minutes.

Abbé Spallanzani went still further, however, and showed that living tissues excised from a freshly killed animal will take up oxygen and give off carbon dioxide for a time, quite as if they were directly connected with the blood stream which brought them oxygen and carried

off the carbon dioxide. In this he anticipated, in certain fundamental aspects, the series of experiments which have been made in recent years to demonstrate that tissues retain vitality for a definite and sometimes rather prolonged period after their detachment from the living being to which they belonged originally. When I add that he was very much interested in the subject of artificial fecundation, which, like regeneration and spontaneous generation was to occupy biology so much in the last century, it is quite easy to understand how far ahead of his time he was. He was undoubtedly the most important pioneer in experimental morphology, that department of biology which came to attract so much attention in the last quarter of the nineteenth century; though his work on this subject began a full hundred years before that time.

Spallanzani's early education and his youthful intellectual interests were not such as might naturally lead him into experimental science. Indeed, his thoroughly classical education was such that, to believe certain modern theorists in education, it might have been expected that he could not have developed that interest in the things of nature around him and the marvelous power of observation which characterized his subsequent career. For, as Senebier says in his sketch of him prefixed to the *Memoirs on Respiration*, "he confined himself to the study of grammar, the importance of which in general is not sufficiently felt, informing the mind so as to seize

those relations which are adapted to confer on it distinction or at least happiness."

Spallanzani was born 10 January, 1729, at Scandiano, in Modena, which, with Parma, was then an independent Duchy in North Italy. His college education was obtained with the Jesuits at Reggio; and, after the completion of his studies of rhetoric and philosophy, he went for his university work to Bologna. At that time one of the most distinguished professors at the University of Bologna was that celebrated woman teacher of the natural sciences and mathematics, Laura Bassi. She was a cousin of Spallanzani, and deeply influenced his intellectual development. This mother of twelve children, "who never permitted her scientific and literary work to conflict with her domestic duties, or to detract in the least from a singular affection which so closely united her to her husband and children", was a focus of attention in Bologna that attracted visitors from everywhere.[4]

In spite of this interest in the natural sciences aroused by his distinguished cousin, Spallanzani devoted himself to the classics and especially to

[4] This same century saw no less than three other distinguished women professors at the University of Bologna: Madame Manzolini, professor of anatomy, a colleague of Galvani; Maria dalle Donne, for whom Napoleon established a chair of obstetrics at the University; and Clotilda Tambroni, the famous professor of Greek, of whom it was said "only three persons in Europe are able to read Greek as well as she does."

Greek. His favorite authors were Homer, Demosthenes, and St. Basil; and the first work from his pen was a critique of Salvini's translation of Homer, which had been considered up to that time as one of the best translations of the old Greek poet ever published. Spallanzani showed, however, in how many ways the translator had failed to reproduce in Italian the spirit and vigor and sometimes even the sense of a very great number of Homer's expressions. In doing so he entered into the most erudite details respecting the etymology of a variety of words, pointing out their exact import and restoring the true sense of the Greek text. His letters on the subject constitute a real monograph, and were printed in the works of the distinguished scholar, Conte Algarotti, to whom they were written.

Besides his work in literature and the natural sciences, Spallanzani, conforming to the wishes of his father, whom he dearly loved, took up the study of jurisprudence, so as to follow out the custom of Italy of the son's embracing his father's profession. He was in the midst of his course in jurisprudence when he confided to the well-known Vallisnieri, professor of natural history at Padua, his lack of serious interest in law; and Vallisnieri, who was also a native of Scandiano, and was well acquainted with the Spallanzani family, promised to secure his father's permission to give up law. Deeply affected with the proof of obedience to his will, Spallanzani's father readily consented that his son should

henceforth be left at liberty to follow the bent of his own inclinations. From this time on Spallanzani's life was almost entirely devoted to the study of natural history—what we now call physical and biological science.

At the conclusion of his years with the Jesuits, Spallanzani passed some time with the Dominicans at Reggio, and received Minor Orders there. I have been able to find no record of his ever receiving Major Orders, though he was invariably known as Abbé Spallanzani in all that was written about him in English and French literature; and he seems always to have considered himself as devoted to the Church. He was only twenty-five years of age when, in 1754, he was chosen professor of Greek, logic, and mathematics at the University of Reggio. Such a combination of studies and teaching would seem absurd in our day, and would lead one to think that the poor fellow who had to undertake so various a duty would surely not be able to find any satisfactory self-development. Before five years had passed, however, Spallanzani's work had attracted widespread attention; and the University of Coimbra in Portugal and the Academy of Petersburg in Russia, as well as the Universities of Parma and Cesena in Italy, offered him chairs. He preferred the call of the University of Modena, in his own North Italy, and continued his good work there.

In 1768 the Empress Maria Theresa suggested to her minister of education that Spallanzani

should be secured for the chair of natural history in the University of Pavia, which the great Empress, in her policy of conciliating the Italians who were under Austrian rule, was engaged in reorganizing. Spallanzani hesitated about accepting the offer until he was assured that a most liberal policy was to be instituted as regards the University of Pavia, and that he would be given large opportunities to develop its department of natural history, as well as liberal allowances in order to make the museum at Pavia one of the best known not only in Italy but throughout the world. During his occupancy of the chair at Pavia, Spallanzani, in accordance with this prearrangement, spent a great deal of his time in Switzerland and along the Mediterranean coast, also in Asia Minor and Turkey and Greece, gathering collections of scientific material for the museum at Pavia, which made that a center of interest for Europe and the biological sciences at that time.

Pavia, after having been a very distinguished university, had been allowed to run down under the Austrian domination until it was scarcely more than a shadow of its former greatness. The administrative ability of Maria Theresa made it clear to her that a continuance of the previous neglect would surely create disaffection among the Italians, and foster revolution. Hence the issuance of the invitation to Spallanzani, with the offer of such special opportunities in his line as would surely secure his acceptance. Some

idea of her success in gathering a band of distinguished professors at the reawakened University of Pavia may be gathered from the group of men who came there in Spallanzani's lifetime—including Boscovich, the great mathematician; Fontana, the naturalist; as well as Burserius and Moscati.

Vallisnieri, professor of natural history at the University of Padua, who was considered the most prominent teacher of the biological sciences throughout Europe, having died, his chair was offered to Spallanzani—a compliment which implied that the faculty regarded the professor of Pavia as the legitimate successor of his great compatriot. Spallanzani was tempted to accept the position, because of the prestige that went with it; but the Empress of Austria wished to retain him, and the Austrian authorities doubled his salary, and offered him a long leave of absence for a scientific expedition to Turkey, knowing well that this latter stipulation would carry far greater weight with Spallanzani than any monetary consideration.

He remained at Pavia, then, and accomplished a long scientific tour throughout Turkey, his return being made the occasion of a magnificent university ovation. After this at regular intervals he continued to make scientific journeys, always with definite investigation purposes. He made a series of special studies, for instance, of Vesuvius and of the volcanoes of Sicily and of the Lipari Islands; for he was interested not

only in the biological sciences, but in all the physical sciences.

Abbé Spallanzani's most important work in his time was the collection of specimens for the museum of the University of Pavia. In this task he anticipated what was to be a particular feature of university scientific life at the end of the nineteenth and the beginning of the twentieth century. As there was practically none of the natural sciences in which Spallanzani was not interested, the specimens he collected illustrated every phase of natural history at that period. He made a great natural history museum in the broadest sense of the word; and the surprise is that a man so deeply interested in collection, comparison, and classification of the objects for a museum, should at the same time have been so indefatigable an experimenter, and so ingenious an organizer of experimental methods of all kinds. There is scarcely a biological question that has deeply interested scientists during the past generation which, apparently, did not occur to Spallanzani, and which he did not make some attempt to answer. Even when his attempts are failures, because of the state of science at the time, almost without exception his methods are suggestive.

There was a very large group of Italian scientists doing magnificent work in the latter half of the eighteenth century. We have been so little accustomed to consider Italy as the pioneer in nearly all great scientific achievements that we

are not likely to appreciate this phase of the history of science. Among those whose work was attracting world-wide attention among his fellow-countrymen in Spallanzani's lifetime were Galvani, after whom galvanism is named; Volta, whose name has been chosen, and meritedly, as one of the basic terms in electricity; Morgagni, the father of modern pathology; Scarpa, the greatest anatomist of his day; Vallisnieri, the naturalist; Mascagni, and others. It was in a generation of this kind that Spallanzani was properly appreciated, and looked up to as, if not the most distinguished among them, certainly the one with the greatest breadth of knowledge and probably the widest reputation in his own time.

Dr. Tourdes, of the University of Montpellier, who knew Abbé Spallanzani personally, and who translated a number of his works into French, in his sketch of the literary productions of Spallanzani which precedes his translation of the Abbé's experiments upon the circulation of the blood, has a series of paragraphs which demonstrate Spallanzani's contemporary reputation.[5]

[5] This work, with a number of others, including most of the important books published by Spallanzani, as well as some of his unpublished manuscripts which were edited after his death, can be obtained in English translation. Indeed, there is scarcely any language in Europe—that is, of the more important countries—into which most of Spallanzani's works were not translated. It is no surprise to find them in English; for during the later seventeenth and eighteenth centuries English and Italian science were rather closely in touch

Italians were certainly among the first to do justice to their fellow-countryman. They had the highest opinion of his merit, and the writers of that country participated in the general admiration of Spallanzani. It was impossible that the greater part of them should not be conscious of their inferiority; and such men as Volta, Scarpa, Moscati, Fontana, and Mascagni, could have no reason to envy his glory.

Foreign naturalists likewise paid him the most honorable tribute of praise. Haller dedicated to him one of the volumes of his immortal work. The founder of the most magnificent edifice that has ever been erected to the science of man owed, doubtless, some mark of acknowledgment to one who had furnished him with such a number of materials. "You have discovered to us," said Bonnet in a letter to him, "more truths in a few years than whole academies have done in half a century." This observation, too, was made before Spallanzani had published his mineralogical productions, his chemical essays, or his various papers in natural history.

Spallanzani was intimately connected with Trembley, Saussure, Tissot, and the French scientists of his time. Everyone knows the esteem and attachment entertained for him by Senebier, the illustrious librarian of Geneva. The familiar friend of Spallanzani, and an enlightened judge of his merit, he incessantly celebrated his discoveries, extolled his talent in the experimental art, and enriched with the most instructive notes the translations which he gave of almost the whole of his works.

The Germans and English have done equal justice

---

with each other; though, it must be confessed, with the obligation entirely on the part of the English toward the Italians, who honored themselves by honoring such men as Malpighi, Morgagni, Galvani, and Spallanzani.

to the Professor of Pavia. The former have confirmed by experiments almost all his discoveries; the latter, notwithstanding their prejudice against the inquiries of foreigners, have been compelled to acknowledge the importance of his observations on organic reproduction, digestion, generation, etc.; and they have translated his works upon these subjects into their own language.

But France, beyond every other country, claims the merit of having assigned to this elebrated man the honorable rank which he will occupy in the annals of history. No sooner were his works known to this nation, than it appropriated them by translations executed with elegance and fidelity. His discoveries were never mentioned but in terms of admiration, and they were adopted almost with implicit belief. His name resounded in all our schools, and it was everywhere heard with enthusiasm.

One of the theses (No. 59) for the Faculty of Medicine at the University of Paris, written for the Doctorate in Medicine in 1912, had for its subject "Spallanzani the Biologist". In a comparatively short space this thesis reviews particularly Spallanzani's contributions to the sciences related to medicine. It enumerates no less than four opuscules of Spallanzani on the circulation of the blood published between 1768 and 1775. His special work on digestion I have already noticed; and it was illuminated by his experimental methods, which included the inclosure in tubes, closed by wire netting, of digestive materials, which were thus exposed to the action of the gastric juice of the animal, and might afterward be recovered for the study of the comparative effect of digestive secretions on these

materials. His experiments on respiration were not less ingenious, and always brought concrete knowledge. Indeed, it is the ingenuity of his experiments that attracts attention at the present time.

One of Spallanzani's very dear friends and admirers was Senebier, who was the librarian at Geneva, a corresponding member of the National Institute of France, and member of a number of academies. We owe to him a sketch of the literary life of Spallanzani, and he has summed up the great scientist's influence on his time:

If we are to judge Spallanzani by the number of his works, he is phenomenal. If we turn to the subjects which have occupied him, they are the most important and the most difficult that could be; for he has added to our knowledge of the generation of animals and of plants and the circulation of the blood, digestion, animal reproduction, spermatic fluids, microbes, mineralogy, volcanoes, combustion. He has described a number of animals hitherto unknown, and a large number of crustaceans and testaceans, besides providing the solution of many physical and chemical problems hitherto misunderstood.

If we are to judge him by his method, that is at once the most ingenious, the easiest, and yet the most severe. He never leaves any doubt behind, and his explanations are always solidly founded. It is only in the universality of his labors that we can see his vast conceptions, which are always the happy development of a great idea which flows naturally from some of the great principles of natural history. One might well be persuaded that, somehow or other, he possessed the plan of the universe, from which he detached parts here and there in order to put them under the

eyes of ordinary people. Finally, if we are to judge of Spallanzani by his style, we have here another characteristic trait of genius; for the man who can see clearly expresses himself well, and his style is pure and clear, yet colored and melodious. His compatriots place his works beside those of the best writers in Italian.

The writer of the thesis at the University of Paris, Dr. Jean Rosenwald, says in conclusion as to Spallanzani: "If genius, as Buffon said, is the power of continuous attention, or if, as Thiers declared, genius has no specialty, Spallanzani fulfils these definitions better than any one else. He cannot but appeal to us, and there is no eulogium which is more correct or more deserved than that which styles him the precursor of Pasteur as well by the depth of his researches, the precision of his experiments, and the sagacity of his deductions, which leave very little for criticism or for sincere controversy. It seems too bad, then, that Lazaro Spallanzani should have been in the penumbra in which modern history has left him; for a place in the full light is due to this illustrious man and giant pioneer of human progress."

V.

ABBÉ BREUIL AND THE CAVE-MEN ARTISTS.

VAIN was the chief's, the sage's pride!
They had no poet and they died.

—POPE.

They had an artist and they lived.

NEQUE solum vivi, atque praesentes studiosos discendi erudiunt, atque docent: sed hoc idem etiam post mortem monumentis litterarum assequuntur.—CICERO.

Learned men not only instruct and educate those who are desirous to learn, during their life, and while they are present among us, but they continue to do the same after death by the monuments of their learning which they leave behind them.

V.

ABBÉ BREUIL AND THE CAVE-MEN ARTISTS.

THERE has been a very surprising—one might well say almost astounding— development of science intimately concerning man, during the last few years, which comparatively few even of educated people have realized. A good many of the publications with regard to it came shortly before the war and unfortunately the war has so occupied men's minds all over the civilized world that almost nothing else has had any proper chance for consideration. Besides blockades of various kinds, the high cost of living and the high prices of many things have prevented the diffusion of the literature of the subject. Shortly after the war, however, I feel sure that this will prove one of the most startling revolutionary scientific developments that have come to us for many generations, if not indeed for many centuries. It consists of what we have learned with regard to the earliest ancestor of man in Europe, that is, the dweller in caves, whose mode of life and something even of his mode of thought have been brought home to us by the wonderful discoveries made in the Dordogne in Western France, as well as in Northern Spain and in certain parts of the South of France.

That from the very beginning it may be clear that I am not exaggerating the significance of

this set of discoveries, it seems well to quote a recognized authority in the matter, a man who, though himself not engaged in this particular field of archeology, is eminently in a position to estimate the significance of the discoveries made. I suppose that it would be generally acknowledged that the address of the President of the British Association for the Advancement of Science each year is looked upon, in the English-speaking world at least, as the paramount scientific message of the year. The position is occupied in rotation by the men who have distinguished themselves in the various scientific bodies that constitute the membership of the Association, so that about once every dozen years or so there is a review of each important department of science. The President in his annual address brings up to date all the significant knowledge in his department and presents a forecast, from the standpoint of a leader in the science, of the outlook of that special mode of human knowledge. The well-known conservatism of the English mind makes these recurring reviews of very great value for those who from outside the particular science desire to know exactly what the meaning of the previous decade's work in it is.

The President of the British Association for 1916 was Sir Arthur Evans, the archeologist, and his address had for title, "New Archeological Lights on the Origins of Civilization in Europe". Almost needless to say, if, as we are all pretty well agreed, "the proper study of man-

kind is man", this review of the earliest positive knowledge that we have with regard to man in Europe, from the actual remains that are to be found, can scarcely help but be of the greatest possible interest. Sir Arthur Evans is himself a man who by his excavations in Crete has added many precious centuries, even a millennium or more, to the history of mankind. For Crete has proved to be a veritable gold mine of archeological information. On that island was found the connecting link between Egyptian and Grecian civilization, and many Greek problems hitherto insoluble become ever so much simpler in the light of the illumination from Cretan discoveries.

He is therefore, as I have said, in a particularly favorable position to judge critically and yet sympathetically of the other investigations made by archeologists throughout Europe, and he accords the palm for significance in the entire round of the science, whole-heartedly to the work that is being done in the caves of the Dordogne and of North Spain, in the discovery of the remains of the earliest man that we know in Europe, and to the bringing out of the meaning of the objects and conditions found in these caves. Sir Arthur Evans does not hesitate to say that these remains indicate "a high level of artistic attainment in Southwestern Europe at a modest estimate some 10,000 years earlier than the most ancient monuments of Egypt or Chaldea". The President of the British Association for the Advancement of Science in his formal

annual address does not hesitate to add that not only were there men in Western Europe who lived 10,000 years earlier than the earliest date ascertainable with any degree of assurance in Egypt or Chaldea, but these men were artists bent on making their homes beautiful, and, besides, "one by one characteristics, both spiritual and material, that had been formerly thought to be the special marks of later ages of mankind, have been shown to go back to that earlier world".

Here indeed is the greatest surprise of modern science. Whatever is to be thought of the dates suggested (for they remain to be determined by further investigation, and dates in archeology have a definite tendency to come nearer to us rather than to go farther away from us as we know more about the history that they mark), one thing is sure, namely, that the men who lived in the caves of Western France and Northern Spain were the contemporaries of many extinct animals—the mammoth, the cave bear, the sabre-toothed tiger—and during a time when an animal very close to them in the Pyrenees was the reindeer which has long since abandoned a habitat so far South as this anywhere in the world.

Now it is extremely interesting to find that the two men to whom we owe by far the greatest part of our knowledge of these cave men—Abbé Breuil and Father Hugo Obermaier — are both priests; the one a Frenchman, and the other a

German. The story of what they have done in adding to our knowledge of man's existence in Europe is one of the romances of modern science. Nothing has been a greater shock to preconceived notions than the discovery that so far from the ordinary accepted view of the cave-dweller of the olden time being true, it is separated *toto coelo* from realities. Instead of having been only a bit higher than the animals, this earliest man we know by his remains was as a matter of fact an artist and in every sense of the word as highly developed a human being as we are ourselves.

His cave homes were discovered to be decorated with beautiful pictures and figures of animals and occasionally of men and women as well as of the natural objects that surrounded the cave man in his life. These pictures are not crude and childish, though they are primitive; but, then, the primitives in art have come back into favor and critical appreciation so strikingly in recent years that it is much easier to understand than it was a generation ago that primitive painting may be great painting, and there is now universal agreement on the part of the artists and critics that the cave man did great painting. A distinguished artist said not long since that there is no animal painter alive to-day who can paint animals more vividly, more true to the life, more artistically in any genuine sense of that term, than the cave-man artist.

The artist is the flower of our civilization such as it is, and we are quite willing to acknowledge that a man who is capable of seeing the beautiful things of the world around him and reproducing them so as to give pleasure to others is a leader among men. He may be the son of a little pioneer farmer who secures his first colors from the Indians dwelling near him, whose portraits he makes, as our own Benjamin West did; or he may be brought up in a stone mason's family as Michelangelo was and learn his first use of the chisel and mallet for the crudest mechanical purposes; or he may be the son of peasant farmers who remains a peasant at heart and never gets out of sympathy—thank God!—with his peasant relatives, like François Millet, the great French artist of the end of the nineteenth century. But whatever he is and no matter what his education or refinement, we look upon the genuine artist as much more than an ordinary man, as one of the highly gifted beings of his generation. Now there is no doubt at all that the cave man was, or at least the artists of his time were, just such superior individuals. Before he was a carpenter and built himself houses, before he was a farmer and planted seeds instead of gathering the natural produce of the woods, before he was a tailor and fashioned his garments to fit his body, merely dressing himself in the skins of the beasts that he hunted, *man was an artist, a lover of the beautiful, a decorator of his home, a man among men for all time.*

Is it any wonder that this new appreciation of the earliest ancestors of man that we know anything about is considered to be the most revolutionary development in modern science. Just consider for a moment how different are the realities from the theories that had been woven for us and that had been so widely and frequently published that practically everybody was inclined to think that they must represent quite serious scientific truth. The cave man had been pictured to us as the first stage in the evolution of human beings from the beasts. Some large-sized monkey who had acquired the habit of walking on his hind legs, developed cunning enough to displace the other wild animals from their lairs in the caves of the hillside and thus begin domestic life and an upward career toward civilization. He was a little better able, because of his recently achieved cunning, to care for himself and his family than were the other beasts; but he was at best a very pitiable object. His wife, doubtless a conquest of his club, he had probably dragged home to his cave by the hair of her head to keep her there in the most absolute subjection and drudgery in order that she might be the mother and caretaker of his children. Popularizers of science are still telling us stories of the cave man quite as if they were truths and not fables. The very same people would laugh at the myths of savages (though so many of those myths contain a kernel of marvelous beauty), but they are quite unconscious

that they are myth-making and that their myths are quite sordid and unworthy of humanity's striving.

Above all, we have heard a great deal about the cave man and how far humanity has advanced since his day. He was supposed to be ready to quarrel on the slightest provocation and to be always in readiness to get the other man first so that *he* might not get him. Of course it was clear on these assumptions that the cave man was quite without the ethics which characterize civilized man and which are so confidently asserted to be the gradual development of man's recognition, as his evolution progresses, of his duties toward other men. We have a nice long name for it in our time adopted and adapted from the Greek, so as to make a very simple old-fashioned idea appear important and novel. We call it altruism. Of course the cave man is supposed to have had none of it. He was merely selfish, as the animals are; for all that the animals think of is themselves and those separated parts of themselves, their offspring. The cave man was a slightly better beast.

Now we have changed all that, as the French say; at least we ought to proceed to change it at once, for the archeologists have shown us very clearly that the cave man was just a man like ourselves, only, if anything, somewhat more cultured in his interests. For his devotion to art and the beautiful things round him, and his desire to reproduce the living things of nature

round him, in which he rejoiced so much that, even in the winter time when the weather made the chase impossible and on rainy days when confined at home, he wanted to see them on the walls of his cave, stamp him as a superior being.

We owe most of our knowledge of this new set of ideas, founded on actual observation with regard to the cave man, above all to two great scientists, both of whom, as I have said, are priests. In the divided state of feeling that separates cultured humanity at the present time, superinduced by a war that contradicts so strikingly the ideal progress of which we hear so much, it is of more than passing interest to find that one of these is a Frenchman, a representative as it were of the Allies, Abbé Breuil, and the other a Bavarian, quite as sincerely representative of the Central Powers, Father Hugo Obermaier. When shall we be able to have such coördination and coöperation in the great scientific work after the war once more?

Manifestly this revolution in our knowledge of man deserves to be well known, above all by those who have maintained a conservative attitude in their philosophic opinions as to the origin of man and have waited patiently for anthropology to develop properly, though they were being pushed into premature opinions by so many supposedly authoritative scientists who were urging the most radical notions. Brother priests all over the world should surely know the facts, for not only do they represent one of the

greatest triumphs of science in our day, but they confirm traditional opinions that for so long were looked upon as hopelessly backward. Not that it is unusual for priests to be distinguished in science. On the contrary, a knowledge of the world of a half-a-dozen modern priests would give one an encyclopedic knowledge of modern scientific advance. Abbot Mendel, Father Secchi, Father Wasmann are names that make this very clear, and now we must add two more to them—Abbé Breuil and Father Obermaier, who, while following faithfully priestly and ecclesiastical duties, have given the world such ripe fruits of their scientific research.

Abbé Breuil and His Work.

Abbé Breuil was born 28 February, 1877, at Mortain, in the Manche, of a family many of whose members of preceding generations had belonged to the magistracy of Picardy. From his very early years he manifested a marked taste for natural history, and above all took up quite seriously of his own volition the study of entomology, to which he later did distinct services by collecting the subterranean fauna of the caverns as also of the Spanish territories surrounding the habitations of the cave men.

His college studies were made in the Collège Libre of St. Vincent at Senlis. He entered the Seminary of St. Sulpice of Paris in 1895 at the age of eighteen. Abbé Guibert noticed very soon his liking for the sciences and gave him special

opportunities and recommended that he direct his attention toward archeology and the earliest records of human existence. Abbé Guibert was himself the author of a volume on origins (*Des Origines*), which concerns itself, however, mainly with apologetic problems.

During his vacations Abbé Breuil had the opportunity to associate himself with some of the distinguished men who were doing the best work in archeology in Paris at that time. He came to know and receive the directions of such men as Capitan d'Ault-du-Mesnil, Salomon Reinach, Boule Gaudry, and these associations gave a strong impetus to the interest in archeology which had been aroused by Abbé Guibert. Above all, young Breuil had the magnificent advantage of becoming the intimate friend of Edouard Piette, that great searcher of the Pyrenees caverns, who exercised a very special influence over him and indeed adopted him as a student and disciple. Their intimate relations to one another until the death of M. Piette in 1905 directed Abbé Breuil's work, particularly in the line of the artistic archeology of the caverns and to the study of what is known as superior paleolithics, because it concerns itself with art objects rather than merely with the remains of the crafts of the olden time.

Abbé Breuil's first scientific publications began in 1898, when he published an article on the chronological status of the Bronze Age. After 1901 all his attention was devoted to the Old

Stone Age and especially to the higher art and industry of that time. He was ordained at St. Sulpice in December, 1900, but remained at Paris for the next five years studying for his degrees in science and taking special courses at the Catholic Institute. From 1905 to 1909 he was a Privat-docent at the University of Fribourg in Switzerland. His special subjects were Prehistory and Ethnography.

Since 1901 about one-half of Abbé Breuil's time has been occupied with the actual investigation of caverns, alone and with Capitan and other well-known archeologists. A large number of caverns adorned with designs or paintings have been found, the reproduction of which and the description of their surroundings as well as the deciphering of their meaning have fallen upon Abbé Breuil almost alone. Cartailhac called Breuil to collaborate with him in the caverns which were found in the French Pyrenees and together they discovered a number of others in the same region. In 1902, with Cartailhac, Abbé Breuil was invited to take up the study of the celebrated cavern of Altamira in Spain. In 1906 he returned to Spain to pursue new researches in other caverns of the Cantabrian Province with Alcalde del Rio, their discoverer. During the following year he was very much occupied with the paintings discovered in large numbers after systematic search of caverns in Aragon, Catalonia, Estremadura, Castile, and Andalusia. In 1909 he was asked by the Prince of Monaco

to take a post in the foundation created by that liberal patron of the sciences, the Institute of Human Paleontology. Most of his best work since then has been published under the patronage and at the expense of the Prince.

To him more than anyone else is owed the recognition of the significance and the importance of the Aurignacian level or horizon in cave-man archeology, a period which preceded the Solutrean and followed the Mousterian. He worked out the application of the idea of a certain development of style in the engraved figures on the various objects picked up in the cave. He pointed out a certain development from the reproduction of the natural image by the engraver to a schematization of the mode of ornament in the moveable paleolithic art. For the first artists saw things for themselves and reproduced them simply as they saw them. John Ruskin once said that this was the hardest thing in the world to do. Then their successors after several generations refused to follow the difficult path of personal observation, but they looked through the eyes of those who had seen before them, imitated their pictures, took short cuts to get the results, schematized, and of course art degenerated. This is what men have always done; so far from being surprising that some of the cave men should have done it, the surprise would have been if they had not done it. We know in our time how tempting it is for men to take such short cuts and then think, because they are get-

ting more or less the same results, that they are doing just as good work as their predecessors, though their work is really trivial, cheap copying and easy imitation.

Abbé Breuil's work has been very widely recognized and highly complimented. While he has occupied himself almost exclusively with the scientific aspects of paleolithic archeology, a great many other names are much better known because they have devoted themselves to the vulgarization of the newly acquired information. Vulgarization seems a very good word to employ, though we call it popularization in English; for there is an innuendo in the other word that deserves to be recognized. Practically all the authoritative writers on the subject, however, Dechelette in his *Manuel d'Archéologie Prehistorique,* Salomon Reinach in his classical works, and many others, have expressly outlined their obligations to him, and Professor Henry Fairfield Osborn in his *Men of the Old Stone Age* dedicated that book to "Emile Cartailhac, Henri Breuil, and Hugo Obermaier, his distinguished guides through the upper paleolithic caverns of the Pyrenees, the Dordogne and the Cantabrian Mountains of Spain". He confesses that his main reliance has been upon the work of Abbé Breuil and Father Obermaier, and his book is full of references to their published books and articles.

Abbé Breuil has published much in the journals—*L'Anthropologie, La Revue Archéologique,*

La Revue de l'Anthropologie, as well as in the volumes issued under the patronage of the Prince of Monaco. Much of the material, however, that he has gathered from the caverns is still unpublished. Besides, a good deal of work has appeared in collaboration with others. At the International Congress of Archeology, held at Monaco in 1906 and Geneva 1912 to discuss the whole subject of the archeology of the cave man, his industries, his arts and crafts, his colored paintings, his movable and parietal art, Abbé Breuil was considered by all those present as by far the best informed man on the whole circle of departments of knowledge that have gathered round the subject of this earliest ancestor of man in Europe. He has not only visited practically all of the caves, but he has also studied the collections in the various countries of Europe, not only in France, Switzerland, and Spain, but also in Germany, Austria, Hungary, Italy, and even Russia. No wonder then that he is looked upon as an authority on the subject and that a comprehensive view of the significance of the life of this earliest ancestor of man in Europe is now readily available to all who want to replace the ridiculous theories foisted upon us by over-confident evolutionists, by actual information derived from the direct observation of the remains of the cave-dweller.

The Caves and Cave-Dwellers.

These cave dwellings must not be thought of as shallow holes in the rocks of the mountains, or even as deeper cavities caused by the loosening of a boulder and its fall. The caves in which the cave men dwelt are much more like our famous caverns of Kentucky, the best known of which is the Mammoth Cave, though none of the European caverns can be compared for variety or extent with our American wonder of the world. Many of the caverns, however, penetrate the rock for a quarter of a mile or a half a mile and even farther. They were the product of the same sort of water activity as produced the caverns of Kentucky, and of course, while the Mammoth Cave is so well known that most people are inclined to think of it as unique, actually a great many caves exist in the State. So it was in the Dordogne and in certain parts of North Spain and in Southern France, where these cave dwellings have been found.

There was plenty of room in them, and some of the living-rooms must have been at a considerable distance from the entrance. Indeed not a few of the pictures are many hundreds of feet from the entrance of the caves. This makes it easier to understand how they were preserved and are now comparatively so fresh and vivid for the study of our time. This, however, makes it only the more difficult to understand how the painting came to be done.

Almost needless to say, at this distance from the entrance the caverns are utterly dark. There is no question of seeing one's hand in front of one's face. How then did the cave men come to make their pictures under such conditions? What sort of light did they employ? Sir Arthur Evans does not hesitate to say that the mystery of the illumination of these caves is astounding. There is no trace of smoke on the wall or ceiling, and yet we may be quite sure that any extensive use of the primitive modes of lighting by torches or oil lamps, such as the making of the pictures would require, could scarcely have been secured without leaving its traces. It is even more surprising to think that in this pitch darkness men should have cared to take the trouble and the time and exercise the patience needed to make their pictures. The difficulties increase the more we know about the circumstances of the cave man's life.

What is very clear from these discoveries, as has been brought out emphatically by Abbé Breuil's studies of the mural art of the caves, is the fact that man, before he was a carpenter so as to be able to build himself a house, or a tailor so as to know how to make himself clothes, was an artist. It is even probable that before he was a farmer in our modern sense of the word he took up the decoration of his home, such as it was. Instead of occupying himself with the domestication of plants or of animals so as to accumulate stores for the morrow and assure

himself for the future, he depended on being able to hunt successfully and to find many edible things in the forest without sowing and reaping them. This is indeed a surprising conclusion to be forced to. Man at the beginning of his known history preferred to satisfy his sense of beauty, the intellectual and artistic side of his being, rather than to assure the satisfaction of his lower nature.

It has been the rule to think that man first cultivated the utilities, or perhaps it would be better to say developed them; and then, having secured himself in a position where he had leisure, he followed the first faint glimmerings of the duty of occupying that leisure with art and poetry and other of the confessedly higher things of life. His soul is supposed to have been developing within him, but at first his mind was as yet inchoate and his body was the one thing that he was looking out for, pushed thereto by his nature. What proves to be true, however, is that his nature urged him first toward artistic things, led him to see what was beautiful in the world about him, to try to reproduce it so that he might have the chance to look at it at times when he was necessarily out of the presence of it, and in general led him to be an intellectual and not an animal being.

The evolutionists have emphasized the animal in man because they did not quite believe in the presence of a soul. Here, however, is the demonstration that man was at least as far away

from the animals as we are, at the very earliest period that we know anything about him in history. As a matter of fact, I think that it must be perfectly clear to anyone who thinks about the conditions under which the cave man developed his art, that he was, if anything, much higher than our generation, for, in spite of urgent necessities, he would not occupy himself with material things to the exclusion of his higher life, though there is a very readily traceable tendency to do so at the present time.

Of course it has always been true that it was not the man who had secured leisure for himself and his children from whom we might expect art and poetry and the higher things. Our artists and poets have come to us almost as a rule from among the very poor, and to a great extent necessity has been the mother of art and invention for them. Almost never have they been cradled in luxury, and practically always they have known, in Dante's words, "how bitter it is to eat the bread of others' tables", and as a rule they have had to struggle with the urgency of material necessities.

Almost literally our great poets and painters have been the cave men of the modern times. They have neglected the utilities of life and have cultivated the higher things. They have not cared to make money, or, whenever they have been tempted into that direction, their gift of poesy has usually dropped from them and their art taste has dwindled. They have been born

oftenest in small towns or in country places. They have been scoffed at because of their impracticalness. They, too, were not carpenters nor tailors nor farmers, because they were artists and poets and preferred to be such even though they had to pay for the privilege of living the higher life by bitter physical suffering. All this, as it seems to me, has been actually brought out by Abbé Breuil's successful investigations of the artistic life of the cave men. When we think of conditions as they are and were, so far as art and poetry are concerned, we realize the kinship and indeed the nearness in every sense of the word to us of this cave man, though we had been taught to think of him as so very distant from us in every way.

Phases of Artistic Development.

After considerable practice with black and white the cave-men artists became dissatisfied with this as a medium and sought to express themselves also in color, and thus reproduce not only the outlines and the character, but the very look of the objects they saw. At first they used masses of black to express the shadows on the animal, and then occasionally to bring out the fact that the animal was spotted in various ways. After a time they found certain ochres that would give them yellows, and then it was not long before they found a way to produce red, and were evidently very much taken with the color. Indeed it is very curiously interesting to

find that after their discovery of colors there was a period of art in which they neglected the drawing which had been so artistically done before. They fairly revelled in their new-found colors, but now did very weak artistic work. The same thing has often happened again in art almost in the later time whenever some new-fangled notions have come in, and it is not surprising that the cave men should have been like subsequent generations in this regard. The surprise, I suppose, should rather be that subsequent generations have not got over the tendency to follow after fads and fancies, very often to the detriment of the art with which they are concerned.

Every step in advance in our knowledge of these pictures has simply added to the astounding significance of them as historical documents. Incredible almost as it must appear, these paintings made by the cave man thousands of years ago are done in oils. The artists, whoever they were, who wished to reproduce as far as possible in their original colors the animals that they saw round them, looked for coloring materials and found that they could obtain the reds and yellows and browns that they desired from the oxides of manganese and of iron. They also found, however, that these materials were not soluble in water. They therefore ground them fine in a mortar—some of the mortars are still preserved for us—and having mixed the powder well with the rendered fat of the animals that they had

killed in hunting, they made what are actually oil colors. Having manufactured brushes out of the bristles of the animals, they painted in oils on the walls of their caves, and their colors were so permanent that, in spite of the lapse of time and the vicissitudes of climate to which they have been subjected (though fortunately, of course, they have been rather well protected deep in the interiors of the cave), they made the pictures that are now the evidence of their high place as intellectual beings.

An extremely significant phase of this mural art of the cave man is to be found in the fact that, in order to give the appearance of plastic rotundity or solidity to the animals that he painted, occasionally the cave artist took advantage of various bosses or rounded projections on the walls of the cave. These were somewhat irregular in outline, though, from their being worn by water, they were rather smooth of contour. The cave artist painted his animals on them in such a way as to produce an illusion of high relief, usually only the horns and tail of an animal in the painting projecting beyond the boss or convexity. The animals had to be placed in various lying poses and the positions of their feet and legs carefully accommodated to the cramped space into which they had to be fitted. The hoofs particularly were studied very carefully, and these pictures show the legs often very well foreshortened. In a word, the cave artist solved both of the most difficult problems of art

for these pictures. It has been very well said that the great artist is, above all, one that can accommodate his art to even cramped conditions. The cave artist wanted to take advantage of the sense of solidity that would be given by these mural projections, so he made his painting fit into the rather confined space.

Vivid Observation.

The art of the cave man, as we have seen, did not blossom into full flower all at once. Definite developments of it can be noted. At first animal figures were executed in what we would call black and white, though, owing to the color of the background of the limestone, it was really gray and white. Lines were cut with a flint in the stone and then lampblack was set in so as to emphasize the line. It is easy to understand that such an outline drawing could exercise artistic ability and call for artistic genius, if good work was to be done. The surprise is how firmly and with what confidence the lines were made. Professor Osborn, Director of the American Museum of Natural History in New York and Emeritus Professor of Zoölogy at Columbia University, made a journey through the cave-dwelling regions of Spain and France during the year just before the war. In his book on *The Men of the Old Stone Age,* he has emphasized above all the confident sure-handed drawing of the artists. He says: "In the drawings in the large on these curved wall surfaces, only part of which

could be seen by the eye at one time, the difficulties of maintaining the proportions were extreme, and one is ever impressed by the boldness and confidence with which the long sweeping strokes of the flint were made. For one rarely, if ever, sees any evidence of corrected outline."

As a trained zoölogist particularly interested in the horse, because the problem of the evolution of the horse has occupied so much space in modern zoölogy, Professor Osborn has been chiefly struck by the acute and accurate observation of this cave-man artist in picturing horses. He says (p. 407): "Only a life-long observer of the fine points which distinguish the different prehistoric breeds of the horse could appreciate the extraordinary skill with which the spirited, aristocratic lines of the Celtic horse are executed, on the one hand, and, on the other, the plebeian and heavy outlines of the steppe horse. In the best examples of Magdalenian engraving, both parietal and on bone or ivory, one can almost immediately detect *the specific type of horse which the artist had before him or in mind, also the season of the year, as indicated by the representation of a summer or winter coat of hair*" (italics mine).

The cave artist was quite complete in his technical equipment, and even artistic in the materials that he adopted as his artistic utensils. A single paragraph of Professor Osborn's book brings this out very well (p. 415):

To prepare the colors, ochre and oxide of manganese were ground down to a fine powder in stone mortars; raw pigment was carried in ornamented cases made from the lower limb bones of reindeer, and such tubes still containing the ochre have been found in the Magdalenian hearths; the mingling of the finely ground powder with the animal oils or fats that were used was probably done on the flat side of the shoulder-blade of the reindeer or on some other palette. The pigment was quite permanent, and in the darkness of the Altamira grotto it has been so perfectly preserved that the colors are still as brilliant as if they had been applied yesterday.

Plastic Art.

The cave artists, however, did not limit their artistic aspirations to engravings and paintings in oil. Their paintings of the animals on the bosses or rounded projections of the walls of their cave show that they had a sense of the plastic in art, and so it is not surprising to find that after a time they attempted to make figures in high relief, and that they succeeded quite as admirably as they did with their painting and engraving. For instance, in the cavern of Tuc d'Audoubert, at the summit of a very narrow ascending passage, where therefore they would be best preserved from breakage or the vicissitudes of time, Cartailhac and Abbé Breuil found two superb statuettes of bison in clay, about 60 centimetres (24 inches) in length, absolutely unbroken and showing the high sculptural ability of this particular cave artist. Abbé Breuil was filled with enthusiasm about them, and they

have been described as of perfect workmanship and of ideal art. Photographs of them have since been reproduced, so that there is no doubt at all of the artistic qualities of them, and the story of the cave man as sculptor is in process of development, just as twenty-five years ago his development as a painter was being traced.

There are, besides these, some bone and horn and ivory sculptures that are very beautiful, vividly natural and sometimes very charmingly finished. Osborn says of them:[1]

> Small human figures again appear in the form of statuettes in bone or ivory, representing the renaissance of the spirit of human sculpture. Some of this work is apparently in search of beauty and with altogether different motives from the repellent feminine statuettes of middle and late Aurignacian times, for the subjects are slender and the limbs are modeled with relative skill. As in the earlier works, there is a partial failure to protray the features, which is in striking contrast to the lifelike treatment of animal heads. Very few examples of this work have been found, and most of them have been broken. To this period belong the Venus statuette of *Laugerie Bass* and the head of a girl carved in ivory found at Brassempouy (Fig. 237), with the features fairly suggested and an elaborate head-dress.

A procession of six horses cut in limestone under the sheltering cliff of Cap Blanc, is by far the most imposing work of Magdalenian art that has been discovered. They are thus described by Professor Osborn of Columbia, who saw them

[1] Op. cit., p. 433.

and who reproduced a picture of one of them in his volume on *The Men of the Old Stone Age* (p. 431):

> The sculptures are in high relief and of large size and are in excellent proportion; they appear to represent the high-bred type of desert or Celtic horse, related to the Arabian, so far as we can judge from the long, straight face, the slender nose, the small nostrils, and the massive angle of the lower jaw; the ears are rather long and pointed, and the tail is represented as thin and without hair; they were found partly buried by layers containing implements of middle Magdalenian industry, and they are therefore assigned to an early Magdalenian date in which animal sculpture in the round reached its climax.

Some of the ivory carving is particularly beautiful. There is a series of statuettes of horses carved on fragments of mammoth tusks that were found in the grotto of Espelugues. These pieces have attracted great attention. Espelugues is near the famous Shrine of Lourdes in France, and therefore a great many visitors have seen copies of these. They represent horses of Celtic type with manes erect. The animals are full of action and life. Authorities have declared that they show such certainty and breadth of treatment as sculptures that they must be regarded as the masterpieces of upper paleolithic glyptic art, that is, of the artistic carving of the men of the Old Stone Age at the highest period of development.

One of these pieces of ivory is the head of a young girl. Quite contrary to our custom in the

matter, young girls are seldom the subjects of cave-man art. This one is notable for many features that are reminiscent of what is most modern in our artistic expression of young women. The mouth is not treated at all; the chin is narrow and rather pointed, though in the profile it projects somewhat; the eyes are slit-like and narrow, and the head is covered by either a rather elaborate head-dress or a suggestion of some curious arrangement of the hair. It has been suggested that decadence in art had begun or that this was the work of a very young cave-man artist. Some of the bone and ivory statuettes show a very thorough appreciation of feminine lines of beauty, with very skilful artistic modeling. One model of a trunk has been called the Venus statuette, and well deserves the name, for the artist who did it evidently viewed the feminine human form exactly in the same way that the great Greek sculptors did, and in accordance with the standards that have interested us ever since.

In these small objects of art the artist's power of adaptation of his ideas to the material which he is employing is very admirable and has often been called to attention. Batons, dart-throwers, and poniards are made of bone and tusks in such a way as to use the material to the best advantage by combining utility with beauty, employing the natural form of the material to bring out artistic points and in general exemplifying the same artistic power that was exhibited

so strikingly in making use of the bosses or rounded projections in the caves in order to produce plastic effects in connexion with the colored paintings. Too much cannot be said of this power of adaptation as exhibiting real artistic genius.

Discovery of the Mural Paintings.

The story of the discovery of these mural pictures in the caves is an interesting little romance by itself. A distinguished Spanish archeologist was some twenty-five years ago engaged in looking for bone and horn remains and other objects that might be of interest, in the debris on the floor of one of the cave dwellings at Altamira near Santander in Spain. For company he had taken his little girl, aged about ten, with him into the cave, and as she got used to the darkness and the light of the torch she ran here and there at play for herself. After a time, however, she went to her father declaring that there were pictures on the walls and asking him to come and look at them. He refused to be disturbed in his investigation of the floor of the cave, and when she insisted concluded that she had been seeing her own shadow on the wall or some other shadows which deceived her with the idea that there were pictures. After a time, however, she succeeded in persuading him to look carefully for himself, and sure enough he found the colored pictures that she described. Some of the most beautiful mural paintings of the cave-man art

have been found in this particular cavern, and the little girl as the real discoverer has found a very definite place in the history of archeology.

When this discovery was announced, it attracted very little attention. First the story was not believed at all. Cave men might scratch rather interesting outlines of animals on horn and bone, but it was too much to ask the world to believe that they had *painted* pictures on the walls of their cave homes. It was concluded that these were either non-existent, the report of them being due to a heated imagination or desire for a sensation, or that they were modern sophistications. It was not until similar wall paintings had been found in caves at other places in Spain and at a number of places in France, so that there are more than a score of caves now known to contain them, that the mural art of the cave man became a definitely accepted department of archeology.

The whole story would remind one very much of what was happening just about this same time with regard to brain anatomy, in Spain. A young man, Ramon y Cajal by name, the first who had ever applied a microscope at a Spanish University, discovered in the later 'eighties the endings of the neurons in the brain, a discovery which revolutionized our knowledge of brain anatomy and made it very clear that cells and not fibers were the all-important elements of the brain. When this discovery was first announced it was received with utter incredulity. Biologists

refused to believe that anything so good as that could come out of Spain. Some of the best biological journals in the world refused to publish Ramon y Cajal's articles, and when finally *La Cellule*, printed at the University of Louvain, published them, the discoveries announced were received with a great deal of scepticism. It was not until Ramon y Cajal went in person to the International Medical Congress held in Berlin in 1891 and exhibited his specimens that, led by such men as Virchow and Koelliker, to whom the specimens had been demonstrated, the biological world accepted Ramon y Cajal's work. In 1900 he was given the prize of the city of Paris by the International Medical Congress and later received the Nobel Prize.

Just as Ramon y Cajal's work was destined to be extended and amplified by others, so the Spanish discovery of cave-man mural art fell into other hands for its development; and above all, the Abbé Breuil, himself an artist, took up the accumulation of information with regard to it and the working out of its significance for the life of the men and women who created it and for whose delectation manifestly it had been made a part of their homes. Fortunately the Prince of Monaco, who is so nobly using the income that accrues from that dubious source of revenue, the Casino at Monte Carlo, in the extension of scientific knowledge, became nearly as much interested in this subterranean science as he is in suboceanic observations, and devoted

nearly as much money to archeology as to oceanography. As a consequence Abbé Breuil has been able to publish some magnificent volumes containing copies in the exact colors of the originals of literally hundreds of these mural paintings as well as other illustrations of the art of the cave men.

Distinguished archeologists and scientists of other departments interested also in the antiquity of man have turned not only to Abbé Breuil's books but also to him personally in order to secure first-hand knowledge of these magnificent contributions to modern science. I have had the good fortune to talk with several Americans who met Abbé Breuil in the course of their own special studies on the subject of the cave men, and all are agreed in talking of him as a very charming man, a thoroughly sincere scientist, a very hard worker, a careful, accurate observer—in a word, a thoroughgoing example of the virtues that a scientist must have if his work is to secure a permanent place in his favorite science. Abbé Breuil is tireless in his explorations, faithful in his reproductions, deeply interested in the diffusion of knowledge with regard to his subject, yet constantly ready to share his knowledge with others and willing to take almost endless trouble in order that foreign scientists may have the opportunities they desire to study the cave man under as favorable circumstances as possible,

I have been told, too, by those who met him of his faithfulness as a clergyman and his recognition of his priestly duties as the most important part of life. Even when on his exploring expeditions he makes it a particular point to arrange if possible to say Mass every morning, and if there are country folk in the neighborhood (for the caves are often situated at a great distance from the towns and even villages) he offers them the opportunity to attend his Mass. Sunday he devotes entirely to his priestly duties among the poor folk of the neighborhood, and his kindliness and zeal win over even men who have been long away from their religious duties. The fact that he should be the head of a scientific expedition of this kind gives him great prestige among the country folk and he uses this in order to influence them for their own good as regards the reawakening of their faith and above all the taking up again of their religious duties.

He is himself almost scrupulously exact with regard to little things relating to his religious duties, as a well-known professor of archeology of one of our great universities in this country, Professor MacCurdy of Yale, told me smilingly. The Professor had spent some time with him one summer. Abbé Breuil said his Mass in the morning, giving Holy Communion to the country folk who may come if they are so minded, and then dons the khaki of his explorer's uniform and proceeds to spend the day in a cave. He comes home at night quite thoroughly tired and

hungry, but he is not willing to sit down to his evening meal until he has doffed his khaki and reassumed his cassock so that he may be once more the ecclesiastic. He does this even though at times it would seem to be an over-meticulous regard for ecclesiastical regulations and a following of rule from which it would seem that under the circumstances he might dispense himself. He never seemed to think so.

The interesting fact to me when the story was told to me was that, though it was told smilingly, there was evidently a deep-seated feeling of respect and reverence for the man who took his sacred obligations so seriously that he would not dispense himself from them even in such slight matters as might easily be passed over without scrupulous regard. And this is the man to whom modern science owes one of the most remarkable phases of its recent development.

VI.

THE REV. HUGO OBERMAIER: THE TIME AND PLACE OF THE CAVE-MAN IN WORLD HISTORY.

WE are deceived by the shadow, we
see not the substance of things.
For the hills are less solid than
thought; [and art]
Back of the transient appearance
dwells ineffable calm,
The utter reality, ultimate truth;
this seems and that is.
—DON MARQUIS, *Dreams and Dust.*

AUGESCUNT aliae gentes, aliae
minuuntur;
Inque brevi spatio mutantur saecla
animantum,
Et, quasi cursores vitai lampada
tradunt.—LUCRETIUS.

One nation rises to supreme power in the world, while another declines, and in a brief space of time the sovereign people change, transmitting like racers the lamp of life to some other that is to succeed them.

VI.

THE REV. HUGO OBERMAIER: THE TIME AND PLACE OF THE CAVE-MAN IN WORLD HISTORY.

UNDOUBTEDLY to the Abbé Breuil, as I said in the preceding article, more than to any other, the present generation owes the most precious information in proof that the cave man, our earliest known ancestor in Europe, was an artist. Possessed of no inconsiderable artistic ability himself, Abbé Breuil has carefully and sympathetically studied the examples of art produced by these oldest European artistic colleagues and has reproduced them sympathetically for all those throughout the world who cannot have the precious opportunity to see them for themselves. The distinguished priest's work in this regard has completely revolutionized our ideas about man and has made it very clear that the commonly accepted notions of our own and immediately preceding generations with regard to man's constant progress upward from century to century, if actually not from decade to decade, as some seem to think, are quite absurd and founded on some ridiculous assumptions which prove now to have no foundation in any of the realities of prehistory or archeology.

On the contrary, far from man beginning low down in the scale of civilization, the very earliest man that we know anything about, the date of

whose existence Sir Arthur Evans, President of the British Association for the Advancement of Science, set down as 10,000 years earlier than the earliest date in Egypt, was an artist in the highest sense of that word. He had the artistic sense of beauty, the power of vision, the ability to reproduce his vision, the taste, and even the inventive faculties which the most modern of artists enjoy. In a word, he had all the qualities which, when they appear in a man at any time, no matter what his parentage, or whether he is brought up as a peasant or a farmer, all the rest of the world are ready to recognize as among the highest gifts man can possess, while all those whose critical appreciation is worth while are ready to recognize their possessor as a man among men, far above the average of human kind.

It was extremely important, however, for us to know as far as possible the date at which these men lived and their place in prehistory as regards their known successors in time. These are the men of the Paleolithic time (or the Old Stone Age, to translate that Greek epithet), and we want to know their relations in time and development to the men of the Neolithic period, as well as to the Lake Dwellers, and then the early modern races. It is very interesting to realize that this all-important work in chronology owes more to another priest than to any other worker. Curiously enough, though the caves were situated in Western France and Northern Spain, the man to whom we owe most in the

chronological department of paleolithic paleontology was a German, Father Hugo Obermaier of Munich. He had quite as significant material to work with as Abbé Breuil, who gave himself to the pictures on the walls of the caves, only it required more patient and careful study to elaborate the significance of this material and to trace the meaning of the various objects and their relations to all the knowledge that has been gradually accumulating, for more than half a century, with regard to the cave men.

Father Obermaier's merit in this regard has been recognized by the authorities in the subject all over the world. When Professor Henry Fairfield Osborn, Research Professor of Zoölogy, Columbia University, New York, and Curator of Vertebrate Paleontology in the American Museum of Natural History, wrote several years ago his book *Men of the Old Stone Age, Their Environment, Life and Art,* in which the story of the cave man is given in considerable detail, he did so only after having visited the caves of North Spain and of the Dordogne in South France. Then he dedicated his volume to the men who had proved helpful to him in enabling him to secure first-hand information on all these details. That dedication runs: "To my distinguished guides through the upper paleolithic caverns of the Pyrenees, Dordogne and the Cantabrian Mountains of Spain, Emile Cartailhac, Henri Breuil, Hugo Obermaier." How curiously interesting it is to think that two of these three

men whose names are thus placed, and rightly, at the head of the volume of scientific constructive work which has attracted most attention in recent years, are Catholic priests. How different that fact is from the very definite impression so generally accepted that the Church is opposed to scientific development, and especially to science that would lead us to think that man lived on earth so long ago, and that at least priests would not be liberal-minded enough to be the great scientific pioneers in such a remarkable development.

Professor Osborn confesses his obligation particularly to these two priests, and dwells on the amount of information obtained from Father Obermaier. He says in his Preface:

> This work represents the coöperation of many specialists on a single, very complex problem. I am not in any sense an archeologist, and in this important and highly technical field I have relied chiefly upon the work of Hugo Obermaier and of Dechelette in the Lower Paleolithic, and of Henri Breuil in the Upper Paleolithic. Through the courtesy of Doctor Obermaier I had the privilege of watching the exploration of the wonderful grotto of Castillo, in Northern Spain, which affords a unique and almost complete sequence of the industries of the entire Old Stone Age. This visit and that to the cavern of Altamira, with its wonderful frescoed ceiling, were in themselves a liberal education in the prehistory of man. With the Abbé Breuil I visited all the old camping stations of Upper Paleolithic times in Dordogne and noted with wonder and admiration his detection of all the fine gradations of invention which separate the flint makers of that period.

Obermaier's Patient Research and its Reward.

Father Obermaier above all has worked out the significance of a number of remains that at first seemed to be merely accidental forms in nature, and yet when found under the circumstances in which they occurred had a very significant meaning in archeology. At first, as pointed out by Obermaier, the earliest man in Europe, while recognizing the need of artificial aids in the shape of tools, found it difficult to make these for himself and had to be satisfied to help himself with such rude pieces of flint as he found. He was dependent on the chance shape of fragments of flint which he shattered by letting them fall from heights or by letting heavy stones fall on them. He had not yet learned to shape them symmetrically. In the search after the most useful form of flint which could be grasped by the hand for various purposes, a rather characteristic form was evolved of which a great many are found actually in or in close proximity to the cave dwellings. Very soon the cave man learned, however, to shape suitably-sized flints more or less into the form of almonds, so that they could be easily grasped by the hand, there being a rather smooth surface for the palm and a sharp edge leading to a point on the other side. Dr. Obermaier worked out the progress of flint-shaping, by himself learning patiently how to fashion flints for various pur-

poses and thus demonstrating the course of old-time flint tool-making.

Father Obermaier spent some three years in the great grotto of Castillo near Ponte Viesgo in the province of Santander, Northern Spain. Professor Osborn mentions his visit to that grotto with Obermaier as most illuminating. The results of investigations conducted were very fruitful in scientific results. The deposits which filled the grotto presented in cross section altogether some forty-five feet in thickness, reaching from the floor to the roof. Father Obermaier succeeded in differentiating some thirteen layers of distinct interest, and these proved to cover eleven periods of "industry", representing many different kinds of flint tools and other implements. Indeed this grotto, now famous in archeology, provided by itself a magnificent epitome of the prehistorical period of Western Europe from what is known as the Acheulean Age (because the first deposits recognized as belonging to it were found near St. Acheul in France), to the age of bronze in this same part of the country. Father Obermaier has found that the floor of the grotto was possibly used as a flint-making station in the Acheulean and very likely also in Chellean times.[1]

[1] The names applied to the different periods or horizons or industries, as they are variously called, are modern geographic. Aurignacian, Chellean, Magdalenian, Solutrean, Acheulean, are all adjectives derived from places where special finds occurred illustrat-

The tracing of the age of the various layers was accomplished by noting carefully the changing forms of animal life which are to be found round the fireplaces or hearths, and the modifications of the flints in the ascending levels. In the first or lowest of these layers were found only very crude flints. In the second were some artificially worked flints and the bones of the cave bear and Merck's rhinoceros. In the third layer the flints were of still finer workmanship, and quartzites were also used, and Merck's rhinoceros was present, though not in large

---

ing some special level of prehistoric culture. The Aurignacian industry, as it is termed, is based on the Aurignac man so-called, of Combe-Capelle, who was found decorated with a necklace of perforated shells and surrounded with a lot of fine Aurignacian flints. The Acheulean and the Mousterian have reference to finds at Acheule and Le Moustier. Magdalenian refers to discoveries at La Magdalene, the most ancient of which occur in the grotto of Placard, Charente. The first harpoons or fish hooks were found at this level, and this important addition to the food supply was apparently followed by a decline in the chase. The Chellean industry, as well as early Acheulean times, came when the river shores and the neighboring forests and meadows were favored by a warm temperate climate, such as is clearly indicated by the presence of the fig tree and of the canary laurel in the region of North Central France near Paris. They hunted the bison or old German *wisent* and the wildcattle, that is, the wild ox or Aurochs, called also Urochs, the *urus* of Cæsar. The Urus survived in Germany as late as the seventeenth century, while a few of the bison or *wisent* survive to the present time.

numbers. In the fourth layer the so-called upper Mousterian was rich in small implements and large tools of quartzite. Merck's rhinoceros was very abundant. In the fifth, sixth, and seventh layers, the lower and upper Aurignacian, there were remains of the reindeer and some burins of flint, with implements of stone and bone and the remains of a human infant. In the ninth, tenth, and eleventh layers there were fine engravings on bone and very artistic engravings on stag-horn. These represent what are called the lower and upper Magdalenian. In the twelfth and thirteenth layers the stag is very plentiful, and in the top-most layer a small triangular dagger in copper was found.

Father Obermaier made a series of experiments with flints which showed exactly how the early flint-workers had gone about producing the forms of flint implements which are now so commonly found. While these men were satisfied at first with the accidental sharp edge that they picked up in quarries, they soon learned how to flake flints and to fashion them skilfully by retouching until they secured a really symmetrical almond form, which fitted the hand very well and made a fine effective tool for a great many purposes. They were able to produce symmetrical instruments with straight, convex, or concave cutting edges at will, until the specialization of their instruments for various purposes must have become a craft requiring a great deal of ingenuity.

The Caves as Dwellings.

Father Obermaier has pointed out the vicissitudes of the history of the cave man in his cave dwelling. He finds that long before these caves were inhabited by man, they served as lairs or refuges for the cave bear and the cave hyena, their homes being shared by a number of birds of prey. Sometimes large numbers of skeletons of these animals are found within the caves, and it would seem as though man must have had a hard struggle not only to drive the animals out but to keep them out in inclement weather. While of course the men and women lived mainly near the entrance to the cave, it is well known that even a short distance from the entrance to such underground workings the temperature is likely to be very uniform and never cold. While it might seem as though cave dwelling would be very unhealthy, Father Obermaier points out that the smallest cave was considerably larger and better ventilated than the small smoky cabins of some of the European peasants of the present day, or the snow huts of the Esquimo.

The principal hardship in cave life was the dampness in the winter time. This could not be expelled in any complete way by fire, because the smoke would have been otherwise impossible to stand. During spring, in times of freshets, the cave men were often displaced from their dwellings and these were made uninhabitable by the seepage of water. But every spring in our time

somewhere in the world, and usually somewhere in the United States, many hundreds and even many thousands of people are driven from their homes and suffer severely because of flood conditions. The dampness of many of the dwellings, however, gave rise to certain arthritic conditions, with swellings of joints, so often called rheumatic in the modern time, though not always with complete justification; and there seems no doubt that the rheumatoid diseases were rather frequent, for bones are found of both men and beasts exhibiting diseased swellings and chronic inflammatory conditions of the vertebræ such as are associated with extreme dampness. It is rather interesting to find that man reacted to a damp environment at that time quite as he does at the present time, and we have not as yet found any remedies for preventing such afflictions.

What Father Obermaier has done for us particularly, besides bringing out the significance of the various objects found in the cave, is to place the epoch at which these various finds must be considered to have happened in the history of the race and of the earth, that is, in the geology of the earth's surface. His book on *The Man of the Early Time*[2] is very well known and forms the basis for nearly all the scientific writing on the subject that we have had in recent years. Father Obermaier has worked out the problems of the relationship of the artistic finds

[2] Der Mensch der Vorzeit.

and other remains to one another and to the human skulls that have been discovered, and has placed the progress and decadence of the races as well as calculated about the length of time that the various strata of culture and geologic horizons in which these remains occur, lasted. For strange as it must seem to those who have been quite sure of the assumption that the cave man was a savage, we know now that not only we have the right to speak of culture in his regard, but actually these patient investigators have been able to trace a series of cultures among the earliest known ancestors of man.

Culture among the Cave Men.

Long before pictures were found on the walls of the caves it had been recognized that the cave man was an artistic artisan, and even something of his startling and marvelous ability in pure art had come to be recognized. Among the very earliest things that were found in the caves and that attracted special attention to the old-time dwellers in them were implements or utensils of various kinds which had been used by the cave men and which bore on them ample evidence that he had an artistic spirit. These objects, bone and horn and ivory and other material, some of which are among the most resistant to the vicissitudes of time that we know, had been preserved in the debris on the floor of the caves. A great many of them proved, when carefully examined and when the dirt that had gathered

around them had been removed, to have on them very interesting engravings, that is, pictures scratched with a sharp-pointed instrument.

It was a good while, however, before the high quality of this engraving came to be generally appreciated. A large number of objects were collected, but the markings on them were supposed to be more or less crude and very primitive misrepresentations of the animals hunted by these early men. Indeed it was only after the discovery of the pictures in oils on the walls of the caves that a more careful study of the smaller objects found in the caves showed clearly that there had been in our hands abundant evidence of the fine artistry of the cave men even before the wall pictures were known. The engravings on bone and ivory and horn were thoroughly artistic in quality in a great many cases, vigorous vivid representations of animals of all kinds presented in many ways and modes of activity.

The cave man then came to be studied from two very different aspects, though these two had many very intimate relations, and the researches were founded, not on theory but on actual study of remains. There was in the caves a mural or parietal art consisting of the pictures in oils on the walls and occasionally the ceilings, and then besides there was the movable art, as it came to be called, consisting of the decorated objects of various kinds which soon began to crowd the museums. While Abbé Breuil did so much, as we have seen in the former article, to develop

our knowledge of the mural or parietal art of the caves, he helped also to bring out the significance of the movable art. It remained, however, for Father Obermaier to trace the evolution of these art objects and to give them their proper places in prehistory. There proved on careful investigation to be a series of various cultures to delineate and of divers horizons of progress and decadence to locate, for early as these objects are in the history of man, both upward and downward artistic tendencies are to be noted in them. All their archeological relations were illuminated by the careful researches of Father Obermaier and above all by his intuition amounting to genius in recognizing and appreciating even minute differences.

What has been found is that the cave man ornamented practically all the utensils and implements that he used, that is, of which we can find any remains. He made drinking cups out of the horns of animals, but before finishing them for use he scraped and polished the outer surface of them and then engraved outline figures of animals of many kinds on the surface thus presented. These were done very vividly and presented the animals in all postures, standing, lying, running, charging, and at bay. No maker of the finest decorated glassware of modern time has ever given more labor and thought to the making of beautiful engraved glass than this cave-man maker of drinking horns. His one idea was to present on them a faithful pic-

ture of exactly what he saw and thus recall, while he was peacefully drinking in his cave home, some of the scenes of the active life in which he had been engaged earlier in the day or perhaps at another time in the year.

What was thus true for the drinking cups may be said also of all the other utensils and implements that we have found. Portions of flat horns were used for the making of ladles and spoons of various kinds, and these too were smoothed and engraved. Long bones were sharpened and made into pins to hold together the skins of the wild beasts in which the cave man and his family dressed themselves. These, too, though presenting comparatively so little surface, were beautifully engraved. We have, for instance, the radius of an eagle, one of the long thin bones of the eagle's wing, some nine inches in length and scarcely more than half an inch in diameter at its widest part, and yet the cave-man artist has drawn on it a most vivid picture of a herd of reindeer.

It should be emphasized, too, that these engravings, especially when done on pins meant for holding skins together, probably added to their utility as well as making them things of beauty. The roughness produced by the engravings on the bone made it more difficult for the pin to slip out and thus added to its security as a clasp. It is a good while now, though it was a long while after the cave man's time, since Horace said,

Omne tulit punctum qui miscuit utile dulci,
he carries off every point who mingles the useful with the beautiful,

but this cave-man ancestor seems to have grasped quite thoroughly the principle that Horace referred to and that has been so often quoted, and appears also to have put it into excellent practice.

Perhaps it should be added that, as has been pointed out by artists and art critics who have studied these remains of the movable art of the cave man, most of it is distinctly impressionistic in character, that is to say, the picture is called up to the mind of the beholder with just as few lines, just as little artistic work as possible. When the herd of reindeer was engraved on the radius of the eagle, one or two of the animals at either end of the herd were pictured completely but all the rest are represented just by a forest of horns as it were, and yet the effect produced is startlingly complete as of a large group of reindeer grazing.

The animals drawn by the cave artist are pictured in all modes of activity and inactivity. There is a wonderful engraving on a piece of flat horn of a mammoth charging. Only someone who had seen often and studied most carefully and had a power of reproducing his vision that has never been excelled could have made this very vivid picture. Only a few lines comparatively are needed for it, but it is eminently effective. There are charging boars and bisons, and

bisons at bay, and other studies of wild animal life that are just as true to nature as they can be. As I said in the previous article, "Abbé Breuil and the Cave Man Artist", probably the hardest thing in the world for the artist to express is suppressed motion, just as the most difficult task for the actor and actress is to express suppressed emotion. Free expression of emotion or motion are much less trying tasks. The cave man could, however, picture very vividly an animal not yet in motion, but with every muscle tense to move, though not yet moving. The pictures are evidently reminiscences of times and events in the cave man's experience when a cornered animal backed away for a moment, or perhaps stood still and got ready to charge. To express this attitude in a few lines is a difficult task indeed, but the man who does it shows that he is an artist of surpassing ability. It is over such achievements of their cave-man colleague that modern artists grow enthusiastic.

The putting of all these artistic engraved pictures on the ordinary utensils and implements of the home raises some very interesting questions. The cave man manifestly believed in trying to make everything around him beautiful. He beautified his home by painting pictures on the walls there. In most cases, doubtless, he had them painted for him, for it is of course extremely improbable that every dweller in the caves could paint such beautiful pictures as we find in them, and quite as unlikely that every

cave-holder, or home-maker so to speak, could make striking artistic engravings on his own household utensils. These decorated materials are found, however, in so many places that it is evident that the cave man felt that the things around him should be beautiful, and so practically all of them called in the artists of the time and the artistic craftsmen to make these veritable objects of art with which they surrounded themselves.

The Irish poet Yeats, when bidding a small group of friends good-bye here in New York a few years ago, reminded us as Americans that though there was so much talk of culture in America, the effect produced on a visitor was the feeling that we were beginning to appreciate how little of culture our people yet had. He even ventured to suggest that there was so much talk about it that it was a little bit like the case of people who talk very much about politeness, for it is only those who are not quite sure of their own manners who make a great to-do about the rules of politeness. He ventured deprecatingly, then, to suggest that perhaps it might be well for us to realize that "there is no real culture in the hearts of a people until the very utensils in the kitchen are beautiful as well as useful".

This is, of course, a standard that does not always occur to a people intent mainly on surrounding themselves in the show rooms of their houses, the drawing rooms and libraries, with

bric-a-brac and "art objects" of all kinds, but it is a standard that, once set up, makes everybody brought in touch with it appreciate that culture is for life and not merely for leisure, that it is for all the people and not merely for the leisurely rich, not to use the adjective idle, so often employed in recent years.

Perhaps the most startling thing of all remains to be said, and that is that of all the generations of men, probably there is no one of whom it can be said that the very utensils in the kitchen were useful as well as beautiful, as it may be of the cave man. He literally tried to make everything that he handled, even the most simple utensils and implements of daily life, beautiful as well as useful. He had the true spirit of art, which in this is a gift of the Creator, who never made anything merely useful, but always added an element of beauty. All the beautiful things in nature around us are eminently useful—the leaves, the flowers, the fur of animals, the feathers of birds, all these are beautiful, often supremely so. There is no need to say, however, that they are also finely useful. The leaves of the trees are the stomachs and the lungs of plant life. We usually do not associate the idea of beauty with stomachs and lungs, yet how marvelously beautiful in their almost infinite variety are the leaves! The feathers of birds are eminently useful, but how charmingly beautiful are most of them! This is true not only of highly-colored feathers but even of the

simple ones. The eyes in the wing feathers of the pheasant are indeed artistic and represent the outpouring of beauty from the Creator quite as if it were impossible for Him to make anything without making it beautiful as well as useful.

It is surprising indeed to find the earliest ancestor of man in Europe thus closely in sympathy with the Divine mind, but it must not be forgotten that the surprise is due entirely to the fact that we have allowed ourselves to be led by modern science, so-called, to believe that man began as a savage and then gradually worked up to our supposedly high stage of civilization, the height of which, by the way, we do not boast so much of since this war began. Until comparatively recent years, say the last two generations at most, it was the custom of man to look back, not on savage ancestors, but on a happier, more peaceful time, a Golden Age from which men had descended. All the poets have this, and it was evidently a commonplace in the thought of men until the theory of evolution came to disturb modern thinking. The Christian background of thought would, of course, rather foster the idea of man early in his history having a fine sense of beauty and a close sympathy with nature even though his material circumstances might be of a character that is usually supposed to hamper artistic expression.

The Cave Man an Inventor.

Of the cave man's ability as an inventor as well as an artist there can be no doubt, for the very fact that he invented painting in oils would of itself exhibit him as an ingenious technical expert in anything that he wanted to do. In all the years that have elapsed since, man has improved but little on the technique of painting in oils. Whenever he wanted to make permanent pictures of his activities he has reverted to the cave man's invention. We have re-invented the process of painting in oils two or three times since at least, but we have not modified it essentially, nor indeed, if we study the cave men's pictures seriously, have we added to its power to express human vision.

There is another invention of the cave man which deserves to be recalled. He is the first human being to whom can be traced the use of fire for heating and lighting purposes. It would not be too much to assume that this earliest ancestor in Europe, subjected to the inclemencies of the weather of the Pyrenees region, must have inevitably developed the means of making fire. What is often not properly appreciated, however, is that the inventor of fire was one of the greatest inventors that humanity has ever had. For fire is literally one of nature's great active agents, and the finding of a way to make it available is then our most important invention. Electricity is as nothing compared to it, though

the use of electricity in recent years has made us so proud of man's ability to adapt nature's agencies to his own advantage. According to the legend, man stole fire from heaven; which has often been interpreted to mean that from above the clouds he secured it first from the edge of a burning volcano. That would be the natural tradition in a volcanic country. But there seems no doubt that the cave man used fire very commonly for a number of purposes. This adaptation of this natural agent, which makes such a good slave yet can be such a tyrannous master, stamps him as quite capable of going to nature for whatever necessities he had. As it is, if we were to rub out fire to-morrow, it would more nearly bring about the end of our civilization than any other single act that could be performed, and the cave man seems to have been the individual who first enabled men to make use in divers ways of this all-important civilizing agent.

Domestic Life of the Cave Man.

The domestic life of the cave man becomes very interesting. Here is a man who makes his home beautiful by painting in oil on the walls of it, and makes too all the implements and utensils of daily use as beautiful as he can make them by simple decorative procedures which do not interfere with their usefulness. It would be hard to think that the life in such a home must be that of the savage or anything but a rather

pleasant existence. Of course we have the popular science theories, the oft-repeated declarations of newspapers and magazine science, those fosterers of pseudo-knowledge which has to be corrected and which serves only to make people more ignorant, that the cave man's wife was a slave whom he had probably dragged home by the hair of the head and kept in his domicile merely to care for his children; but there is not the slightest bit of evidence for this; it is all mere assumption. Granted that evolution from the beast to man is true, then this must be so, the evolutionists declare, and that's all about it.

We have come to realize during the present generation that most of the things that were declared by science or pseudo-science that they *must* be so, are not really so, and we are trying to find out not new theories but new facts. The facts with regard to the cave man's home are accumulating. He tried to make it beautiful. Fortunately, among these pictures, of which of course some at least may have been made by the cave woman, for there is not the slightest reason to think that the cave man alone had a sense of beauty, we have some that give us a good idea of the human beings of that time. These provide an excellent basis for reflection as to the real status of the women of the period, in one regard at least. The cave artist always pictures his women folk as rounded and fat, and indeed rather inclined to be obese. He almost never pictures her without children near her, and his

ideal evidently was the rounded, rubicund, healthy mother of children, and not at all the thin younger woman on whom the modern artist expends his efforts so exclusively. Almost needless to say, only an abiding interest in her and the children could have dictated this.

On the other hand, we have also some, though but a few, pictures from the cave man of cave men. Masculine human beings are always represented as muscular and athletic, thoroughly fit, as it were, but not at all fat. Manifestly, his ideal man was the athlete who could go out and chase the animals successfully and who could compete with any of them in strength of muscle and vigor and rapidity of movement. The contrast between the cave man and the cave woman in this regard is very interesting. The conclusion is almost forced on us that the cave woman sat down at home and cared for her children, lived, as it were, on the fat of the land, and so became stout and rounded, while her lord and master, by the rude strenuous work of the chase and the demanding efforts of the hunt, was thoroughly hardened into athletic fitness.

Such stout women could not very well have been drudges. On the contrary, the rule of humanity has always been that it was when men have succeeded in making it possible by their successful efforts in creating a home life in which their wives did not have to work, that these wives became stout or even fat. Farmers' wives are usually rather thin. The old pioneer

women in America were thin and wiry, though their descendants with more leisure and better eating are getting so fat that foreigners are demanding whether the caricatures of Uncle Sam and his wife as thin and rather scrawny individuals are not a living lie, for certainly even the older American families are not represented very often by such types in our day.

In a good many of the caves that were manifestly the homes of the cave people many split long bones have been found. The one reason for splitting bones is to get at the marrow of them. The marrow even in our time represents a delicacy that is much sought after. Evidently the cave man or his wife had learned the secret of the dietary quality of grilled marrow, and so we have a great many remains of these split long bones. It has been suggested that an indulgence in a diet that contains a good deal of grilled marrow, especially if the individual was not compelled to take very much exercise, would produce a state of obesity such as the cave man sometimes pictured his women folks in, as rapidly as does Huyler's candy in our time. It is only those who have abundant time for eating and the preparation of toothsome delicacies who can take the pains to split bones in order to secure the marrow within them in such easily edible quantities, as readily produces a tendency to corpulency at least. The whole story as thus outlined for us is extremely interesting and Father Obermaier's studies of movable cave art and of the

other objects found in the debris on the floor of the caves has brought out a great deal beyond even this of suggestive information.

Belief in Immortality.

What is even more interesting perhaps is the evidence that these cave men had a very firm and thoroughly practical belief in immortality, for which they were quite ready to make rather serious sacrifices. The bodies of the dead were buried with implements near them to take with them to the other world, and even traces have been found of the burial of food with them for their journey. Not infrequently red pigment of one kind or another is found also in the grave, and the explanation of its presence usually given is that the cave men wanted their dead relatives to look well. What struck them most was the greenish pallor of the dead, and to avoid their appearing with this in another world, where they were as yet strangers, red ochre was buried with them to give them a ruddy appearance.

This may seem to many to be a sign of barbarism and of savagery, but let us not forget that at the present time the undertaker is very careful to make corpses look nice by rouging them and even by padding sunken cheeks and jaws and the like. Human nature has not changed very much in the thousands of years since the cave man's time, and we still want to have our dead look beautiful, just as Hector's mother Hecuba rejoiced over the fact that her

son's body had not been marred in spite of Achilles having dragged it many times around the walls of Troy.

The dead of the cave-dwellers were dressed in their best. Apparently some of their finest implements were placed beside them, and the living were quite willing to make the sacrifice of beautiful things over which many hours of labor had been spent, in the desire to provide their dead friends with the instruments necessary, as they believed, for life in another world. I understand that there has never been a tribe found that did not prove on careful investigation to have some religious ideas and, above all, a sure confidence in a hereafter. The cave men might very well be expected to have had it as well as the others, though this evidence for it has proved rather surprising to a good many people.

War and the Cave Man.

It is interesting to appreciate that the investigation of the caves was interrupted just as it had reached this interesting point by the war in Europe. Just before the war began, a French nobleman and his three sons were engaged in exploring one of the most interesting caves that had been uncovered in recent years. The call to arms at once put an end to the expedition, for two of the sons were called to the colors and the third for preliminary training. I believe that one of the young men has since been killed, another has been wounded, and the father, all of

whose attention is now devoted to patriotic work, is alone. That exploration will never be resumed by the same investigators. Indeed it seems very dubious as to when such researches can be taken up seriously again in France. We are thousands of years after the cave men, with all the progress that is supposed to have taken place since then; but it is war that makes it impossible to go on with the interesting researches of the cave man.

One of the French archeologists, Commont, who has spent a good deal of time investigating the cave man's life and customs during the past twenty years, does not hesitate to declare that the older cave man, the maker of his home beautiful, when that home was only a cave, had no weapons for war. He killed the animals that he hunted by dead falls, that is, by pits dug in the path that the animal was accustomed to follow to water, and then covered with branches and a light layer of dirt so that if the animal were scared he would in his hurry rush upon this light frame-work and then plunge to death in the pit below. The weapons, or rather implements, that are found are for peaceful vocations, the skinning of animals, the sharpening of bones, the graving of bone and horn and the like, but not for war. Could there be any more curious contrast possible than our cave-man ancestor demonstrated as a man of peace, while we as descendants of thousands of years later are engaged in the greatest war that humanity

has ever waged. Verily man is a very curious creature and the more we *know* of him, forgetting our theories and waiting for real knowledge, the more curious and inexplicable he becomes.

When the war broke out Father Obermaier was fortunately engaged in archeological work on the Spanish side of the Pyrenees in connexion with the cave dwellings of Spain, or he might have found it extremely difficult to go on with his scientific labors, and perhaps even have suffered some personal inconvenience. As it is, the pursuit of his research work was sadly disturbed by the war, but his presence in Spain led to the creation for him of the Directorship of the Paleontological Institute in Madrid, where he is continuing his work of classifying, arranging, and bringing out the significance of the many specimens, especially of movable art, that have been found in the caves of Spain.

After even this brief story of his work, with that of Abbé Breuil, and the results which they have produced on human thinking, it is not difficult to understand why the claim should be made that probably no other two men have done so much in our present generation to revolutionize human thought with regard to the history of man as these two faithful clergymen. So far from being hampered in their work in any sense of the word by the ecclesiastical authorities, they have been encouraged, materially aided, and their very priestly character has been of a distinct help to them in their work. They have

done in our generation for man what the Abbot Mendel did for heredity, and their work fills a corresponding place in a particular department of biology. Father Mendel found after a time that he was called to higher things in his own order and left his scientific work reasonably complete, though its significance was not to be recognized for a generation later. These two clergymen have been more fortunate, and practically no one writes anywhere in the world on paleontology and archeology without quoting them.

The respect in which Obermaier is held will be readily appreciated from the fact that, when the war disturbed his work and cut off his connexions with his home country, a position was provided for him in a foreign country, in Catholic Spain, so that he might be able to go on with his precious scientific work during the war. The whole story is extremely interesting from a human point of view, but still more significant because of the light that it throws on the real relations between the Church and Science.

INDEX.

PAGE

ABIOGENESIS 128
Acheulean 190
Adam de Marisco 44
Ages, Dark, Bright.... 101
Agricola..... 92
à Kempis, Thomas.. 92, 94
Albert of Bollstadt..... 32
Albertus Magnus 23, 32, 35, 55, 61
Alcalde del Rio 160
Alexandre de Villedieu 61
Alphonso. Table of— 60
Altamira 160, 177, 188
Altruism 156
Anarchists 89
Archives of Diagnosis. 106
Aristotle. Albertus Magnus on— 56
—— Bacon on— 56
—— Errors of—..... 56
Ars Harmoniae et Discordiae 18
—— *Magna Lucis et Umbrae*..... 18
Art Degeneration 169
—— Impressionistic—. 199
—— Movable— 196
—— Mural— 165
—— "Objects" 202
—— Parietal—..... 196
—— Plastic— 175
—— Primitives in— ... 153
Astrology 66
Astronomers. Papal— 9
Atomic Weights..... 111
Aurignacian 190
Aurochs 191
Authority..... 58
Avicenna 64

PAGE

BACILLUS Bulgaricus 66
Bacon. Academic Career of—..... 40
—— and America 38
—— and the Blessed Virgin 76
—— and the Latin Vulgate 77
—— and Mathematics. 58
—— Arabic 75
—— as Teacher 41
—— at Oxford..... 41
—— at Paris..... 41
—— Bitterness 78
—— Brothers. 40
—— Chemist..... 51
—— *Doctissimus Mathematicus* 61
—— Family..... 40
—— Francis— 51, 69
—— Franciscan 44
—— Genius 83
—— Hebrew 75
—— on Calendar 60
—— Optics 50
—— Physical Science . 50
—— Robert 40
—— Roger ..31, 87, 97, 100
—— Roger and Francis 69, 72
—— Uncle 40
Bacon's Acerbity 79
—— Eclipse 35
—— Imprisonment..... 77
Bartolomeo de Parma. 61
Basel. Council of—... 96
Bassi. Laura—....120, 136
Bathybius 128

	PAGE
Binz. Professor Carl—	107
"Blue Coat Boys"	112
Bologna	95
Bonnet	143
Boscovich	140
Boule Gaudry	159
Brasenose	36
Breuil Career	158
—— Henri—	188
Bric-a-Brac	202
Bridges. Dr.—	72, 74
Brixen. Bishop of—	88
Brothers of the Common Life	91
Bruno. Giordano—	89
Buffon	122, 146
Bursa Cusana	112
Burserius	140
CAESALPINUS	12
Caesar. *Urus* of—	191
Calendar. Julian—	60
Capitan d'Ault-du-Mesnil	159
Cardinalate. Nicholas of Cusa refused—	97
Carriages, Automatic	37
Cartailhac	160, 173
Castillo. Grotto of—	190
Cave Culture	195
—— Implements	195
—— Man and War	210
Domestic Life of the—	205
Inventor	204
Observation	172
of Theory	155
Sculptor	173
—— Men of the Modern Times	167
—— Woman	206, 207
Caves and Cave-Dwellers—	164
—— as Dwellings	193
Celtic Horse	175
Cesarini. Giuliano—	96
Chaldea	151
Charles. Émile—	74
—— of Anjou	47
Charme	66
Chellean	190
Christ Rejected	76
Chymiae. De Arte —	52
Circulation of the Blood	144
Civilization in Europe. Origins of—	150
Clavius. Father Christopher—	10
Clement IV	77
—— VI	24
Clepsydra	108
Clifford. Professor Kingdon—	60
College Endowments	43
Colleges. Mediæval and Modern—	42
Columbus	12, 38, 90
——*The Century of*—	92
Commemoration Essays	46
Common Life. Brethren of the—	93
Commont	211
Copernicus	70, 87
Cousin. Victor—	73
Crete	151
Crusade. Children's—	47
Cues	91
Cultures	197
Curriculum. University—	7
Cusa	91
—— Cardinal Nicholas of—	16, 62, 87
Cusanus's Astronomical Ideas	114
—— Beneficence	111
—— Charity	111
—— Germany. Union of—Pioneer	104
—— Medical Diagnosis	105

PAGE

D'AILLY. Cardinal Pierre—..... 38
Dante..... 20, 102, 167
Darwinism..... 127
Dechelette.....162, 188
Decoration of Utensils 198
Degeneration Cycles .. 169
Deventer 92, 112
Diagnosis. Accurate Methods of— 105
—— in Medical Progress 105
Doctor. Illustrious—. 44
—— *Mirabilis*..... 31, 39
Donne. Maria dalla— 136
Dordogne.....149, 164
Draper. Professor—.. 71
Driesch 127
Drugs. Old—..... 104
Duns Scotus..... 76

EARTH. Orbit of— 103
Earthworms..... 123
Education. Utility in —..... 67
Egypt..... 151
Electromagnetismos.... 17
England. Royal Society of—..... 33
Engraving. Magdalenian— 172
Espeluges. Grotto of — 175
Essays. Commemoration— 47
Ethics..... 156
Europe. Intellectual Development of— ... 71
Eustachius..... 12
Evans. Sir Arthur— 150, 165, 186
Explosives..... 53
—— Harnessing—..... 37

"FASCINATION" 47
Fecundation. Artificial—..... 135

PAGE

Figure 66
Fire and Civilization... 205
—— Invention of— 204
Fiske. John— 101
Fitzacre. Richard—.. 44
Flint-Shaping 189
Floyer. John— 106
Fontana..... 140
Francis of Assisi 79
Frankfurt Diet... 97
Freedom. The New— 90
Friar Bacon 36
—— Berthold of Regensburg..... 48

GALILEO..... 26
Imprisonment of . 80
Punishment of—.. 81
Galvani 53, 142
"Gas" 129
Gasquet. Cardinal—. 77
Generation of Mice 130
—— Spontaneous-..... 128
Gerbert..... 23
Germany. Political Status of— 103
—— United—..... 104
Gilbert of Colchester .. 71
Golden Age 203
Gravity. Specific— ... 110
Greek Fire.. 53
Gregory XIII..... 9, 11
Grey Friars 112
Grosseteste. Robert— 44
Guibert. Abbé— 158
Gunpowder 37
—— Arabs, Hindus, Chinese 53
—— Invention of— 53
Guy de Foulques... 48

HAGAN. Father—. 100
Haller 64, 143
Harvey. William— .. 106
Haüy 53
Health Contagious..... 64
Hecuba 209

PAGE

Hegius 92
Heidelberg. University of—..... 95
Helmont. Van— 129, 130
Henlein. Peter—..... 108
Henry III 47, 48
Herschel. Caroline — 120
Hippocrates. English- 65
Hirsch. S. A.— 75
Hohenstaufen 47
Homer. Spallanzani on— 137
Horace. 198
Horizons 197
Horse. Arabian—..... 175
—— Celtic—..... 175
Hugh of St. Victor 20
Humanities 4
Humboldt 51
Hunter. John—..... 122
Huxley. Professor— 5, 6, 7, 8, 70, 128
Huyler's 208

IGNORANCE. Four Sources of—..... 57
—— On Learned—..... 102
Ignorantia. De Docta—..... 17, 101
Imago Mundi 38
Immortality. Belief in—..... 209
Impressionistic Art.... 199
Imprisonment of Bacon 81
—— of Monks..... 81
Inanitas. Methodica— 64
"Industry"..... 190
Innocent III 76
Inquisition..... 54
Institute in Madrid. Paleontological— ... 212
Iter Celeste 18
Ivory Carving.... . 172, 174

JEROME of Ascoli.. 81
Joachim. Abbot— 20
John... 76

PAGE

John of Dalberg 92
—— XXI 20
Jordanus 61

KIRCHER, S. J. Father— 17
Kircherianum 19
Knowledge. Stumbling Blocks to—.... 57
Koelliker 179

LABORATORIES. Anatomical—..... 13
—— Astronomical— .. 13
—— in the Vatican 8
Lake Dwellers 186
Lancisi 13
Learning. New—..... 4
Lenses. Theory of—. 50
Leo XIII..... 9
Leyden. Professor Ernst von— 106
Light. Propagation of— 51
Little. Professor—.... 46
Loeb 127
Lourdes 175
Lutheranism 94

MABIE. Hamilton— 93
MacCurdy. Professor—..... 181
Machines. Flying—.. 38
Magdalenian 190
Magic..... 66
Magnes, sive de Arte Magnetica 17
Mainz Diet 97
Malpighi..... 12, 143
Malus 53
Mammoth Cave..... 164
—— Charging 199
Manzolini. Madame— 136
Maria Theresa. Empress— 138
Marsh. Adam—..... 44
Marys. The—..... 76

PAGE

Mascagni 142
Mathematics the Key of Science 59
Matter and Form 52
Medical School. Papal– 12
Medicinarum. De Graduacione—..... 62
Medicine. Old-Time Makers of—. 16, 105
Medicorum. De Erroribus— 63
Meistersingers..... 102
Mendel. Abbot— 158, 213
Mensch der Vorzeit. Der— 194
Merck's Rhinoceros... 191
Metchnikoff 65
Meteorology..... 13
Method. Inductive—. 70
Michelangelo 154
Middle Ages..... 39
—— Appreciation of— 34
Millet. François— ... 154
Minnesingers..... ... 102
Mirrors. Properties of— 50
Mivart. George—..... 26
Monaco. Prince of— 160, 179
Monte Carlo..... 179
Morgagni 143
Morgan. Dr. Thomas Hunt— 123, 127
Morphology. Experimental— 135
Moscati 140
Motu Proprio 9
Muir. Patterson— 51
Mundus Subterraneus. 18
Museo Kircheriano..... 19
Museum. Natural History—..... 141
Musurgia Universalis. 18

NEEDHAM. Father Walter—..... 122, 131
Neolithic Period..... 186

PAGE

Newcomes. The—..... 112
Newman..... 26
Nicholas IV. 81
—— V 97
Nicholson 53
Nuremberg Diet..... 97
"Nuremberg Eggs".. 107

OBERMAIER. The Rev. Hugo— 152, 185
Opus Majus..... 49, 74
—— *Minus* 49
—— *Tertium*..... 49
Osborn. Professor Henry Fairfield— 162, 171, 174, 187, 190

PADUA. University of—..... 95, 96
Painting in Oils 173
—— in Relief 170
—— Mural— 177
Paleolithic Time..... 186
Paleontology. Institute of Human— 161
Papal Astronomers... 9, 25
—— Physicians 24
Parliament Responsible 104
Pasteur Anticipated.... 131
—— Precursor of— 146
Pattison. Mark— 42
Paulsen. Professor—. 93
Pavia. University of— 139
Pepsin 134
Peter of Spain 20
Pfeffercorn..... 75
Philebus..... 62
Philippines. Storms in– 14
Physician Archbishop 21
Physicians. Papal— .. 24
Physiologia Experimentalis..... 18
Piccolomini. Aeneas Sylvius—..... 12, 90
Piette. Edouard—..... 159
Pins. Decorated— ... 198
Pius II 90

	PAGE
Plato	62
Poincaré	59
Pons Varolii	12
Pope. Philosopher-Physician—	20
Popes and Science	24
"Preceptor Germaniae"	92
Primitives in Art	153
Progress. Failure of—	57
Psychotherapeutists	67
Pulse Comparison	109
RAMON y Cajal	178
Reflexes. Spinal—	127
Regeneration	117
Reichstag Responsible	104
Reinach. Salomon—.	159
Renaissance	4
Respiration	134
—— Comparison	110
—— *Memoirs on*—	135
Reuchlin	75
Revolt of the Pastoreaux	47
Rhinoceros. Merck's—	191
Rich. Edmund—	44
Roger Bacon and Medicine	63
Roman College	10
Romance of Modern Science	153
Rome. Papal University of—	12
Roux	127
Ruskin. John—	161
SAINT Acheul	190
—— Louis. Crusades of—	47
Salamanders	117, 124
Saliva	133
Saltpeter	53
Santander	177, 190
Sapienza	12
Sarton. Professor—	3
Saussure	143
Scarpa	142
Scharpff	94
Science. Experimental—	54
—— History of—	3
—— Institute of the History of—	27
—— *Popes and*—	24
Sciences. History of Inductive—	72
Secchi. Father—.	13, 158
Seismology	14
Senebier	135, 143
Shelley	116
Sigmund. Duke—	88
Smith. Professor David Eugene—	61, 78
Solutrean	190
"Spallanzani the Biologist"	144
—— Digestive Studies of—	132
—— Experiments Ingenious on Snail and Slug	144 125
—— Hibernation	134
—— Literary Life of—	145
—— Marianna—	120
—— Observations on Earthworms	123
—— on Homer	137
—— Respiration	134
—— Translations	142
—— Volcanoes	140
Spinal Reflex Centers.	127
Statuettes of Bison	173
Stone Age. Men of the Old—	162, 171
Studium Generale	41
Sun. Constitution of the—	102
Swift. Dean—	37
Sydenham	65
Sylvester II	22

PAGE

TADPOLE..... 124
Tambroni. Clotilda—..... 136
Telesio 70
Tennyson 116
Teutonic Knights. Cruelties of— 48
Thackeray..... 112
Theodoric. Bishop— 21
Thiers..... 146
Thomas Aquinas 23, 35, 57, 76
Tissot 143
Tool Making..... 189
Toscanelli..... 90, 95
Tourdes. Dr.—..... 142
Transmutation..... 52
Trembley 143
Trithemius. Abbot—. 113
Troubadours..... 102
Truth: Its Joys 99

UROCHS..... 191

VALLISNIERI 137, 142
Van Helmont 129, 130
Varolius 12
Vatican Observatory... 10
Venus Statuette... 174, 176
Virchow 179
Virgil 129
Volcanoes 140
Volta 142
Vulgarization of Science 162
Vulgate..... 77

WAR. Cave Man and —..... 210
—— No Weapons for . 211
Wasmann. Father— . 158
Water-Clock. 108, 109, 110
West. Benjamin—.... 154
Whewell. Dr.—..... 71
William de Rubruk 48
—— of Malmesbury.... 23
—— of St. Amour 47
Wilson. President— . 90
Wimpheling..... 92
Wisent..... 191
Women in Science 121

YEATS 201
Youth Exhalation 65

261.5
W14
ser.3

7917
Catholic churchmen in
science /J.J. Walsh

261.5
W14
ser.3

7917

Graduate Theological Union
Library
2400 Ridge Road
Berkeley, CA 94709

DEMCO